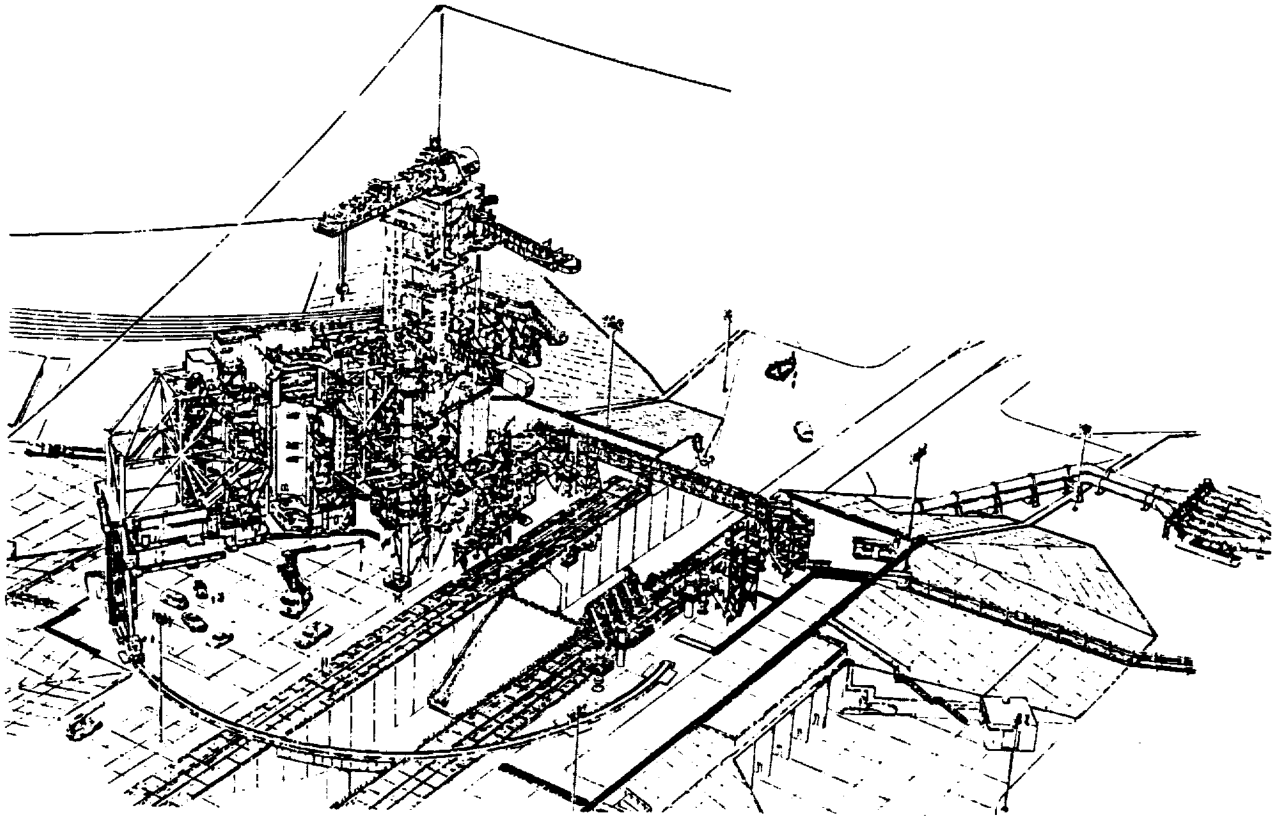
LSO-000-286-1410

KSC ADVANCED PROJECTS & TECHNOLOGY OFFICE

LIQUID ROCKET BOOSTER INTEGRATION STUDY



REVIEWS AND PRESENTATIONS
VOLUME IV OF V

FINAL REPORT
PHASE I

NAS10-11475

NOVEMBER 1988

(NASA-CR-188766) LIQUID ROCKET BOOSTER INTEGRATION STUDY. VOLUME 4: REVIEWS AND PRESENTATION MATERIAL Final Report (Lockheed Space Operations Co.) 959 p CSCL 21H G3/20

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LRBI FINAL REPORT
CONTENTS GUIDE

LSO-000-286-1410

LIQUID ROCKET BOOSTER INTEGRATION STUDY

VOLUME IV OF V
REVIEWS AND PRESENTATION MATERIAL

KENNEDY SPACE CENTER
NAS10-11475

PREPARED BY:
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NOVEMBER 1988

VOLUME IV

REVIEWS AND PRESENTATIONS

This volume contains the material presented at the MSFC/JSC/KSC Integrated Reviews and Working Group Sessions, and the Progress Reviews presented to the KSC Study Manager.

The December 16, 1987 charts were presented at MSFC to support the KSC Project Manager's announcement of the intent to contract with LSOC for the LRBI Study Contract. At the December Working Group Meetings MSFC and JSC requested that KSC host a special Working Group meeting in January 1988.

In response to the December request, KSC hosted the Working Group on the 20th through the 23rd of January. At this time, the LRBI team presented the initial impact assessment to the Working Group Team. This was followed with a station by station tour of KSC processing. This tour identified the significant impact areas and processing work stations to the MSFC/JSC study contractors.

The April 21-22 working sessions updated the total cadre of booster options under consideration of MMC and GDSS. At this update the KSC Ground Systems Impacts were expanded to reflect conflicts with the on-going STS mission. The specific areas reviewed were: access to the LRB at the PAD, the activation schedule, and the transition requirements.

A special cost Working Group meeting was held at MSFC on May 10, 1988. The principal presentations were by GDSS and MMC. Their cost methodology, cost modeling approach and initial life cycle cost were presented. The LRBI presentation provided the first KSC ROM costs. The costs presentation used the same discrete impacts as evaluated by the MSFC contractors.

The last three enclosures of this volume present the Progress Reviews for the period March 15 through December 15, 1988.

LIST OF ABBREVIATIONS AND ACRONYMS

ADP	Automatic Data Processing
A&E	Architectual and Engineering
AF	Air Force
AI	Artificial Intelligence
AL	Aluminum
AL-Li	Aluminum Lithium Alloy
ALS	Advanced Launch Systems
ALT	Alternate
AOA	Abort Once Around
AOPL	Advanced Order Parts List
AP	Auxiliary Platform
APU	Auxiliary Power Unit
ARF	Assembly and Refurbishment Facility
ARTEMIS	Accounting, Reporting, Tracking, & Evaluation Management - Information System
ASRM	Advanced Solid Rocket Motor
ASSY	Assembly
ATO	Abort to Orbit
ATP	Authority to Proceed
AUTO	Automatic
AWCS	Automated Work Control System
BITE	Built-in Test Equipment
BLOW	Booster Liftoff Weight
BOC	Base Operations Contractor
BSM	Booster Separation Motor

C	Celsius
CAD	Computer Aided Design
CALS	Computer Aided Logistics System
CCAFS	Cape Canaveral Air Force Station
CCB	Change Control Board
CCC	Complex Control Center
CCF	Compressor Converter Facility
CCMS	Checkout, Control and Monitor Subsystem
CDDT	Countdown Demonstration Test
CDR	Critical Design Review
CEC	Core Electronics Contractor
CER	Cost Estimating Relationships
CG	Center of Gravity
CH4	Methane
CITE	Cargo Integration Test Equipment
CM	Construction Management
	Configuration Management
C/O	Closeout
	Checkout
CONC	Concrete
C of F	Cost of Facilities
COMM	Communications
CPF	Cost per Foot
CPF2	Cost per Square Foot
CPF3	Cost per Cubic Foot
CPM	Critical Path Management
CPU	Central Processing Unit
CR	Control Room
Cryo	Cryogenic
C/S	Contractor Support
CT	Crawler Transporter
CY	Calendar Year

dBase	Data Base - Software Program
dc	Direct Current
DDS	Data Processing System
DDT&E	Design, Development, Test & Engineering
DE	Design Engineering
DEQ	Direct Equivalent Head Count
DFRF	Dryden Flight Research Facility
DFI	Development Flight Instrumentation
DHC	Direct Head Count
DIST	Distributor
DOD	Department of Defense
DOS	Disk Operating System
DOT	Department of Transportation

ECLSS	Environmental Control & Life Support System
ECS	Environmental Control System
EL	Elevation
ELS	Eastern Launch Site
ELV	Expendable Launch Vehicle
EMA	Electrical Mechanical Actuator
EMERG	Emergency
EPA	Environmental Protection Agency
EPDC	Electrical Power and Distribution Control
EPL	Emergency Power Level
ET	External Tank
ET-HPF	External Tanks - Horizontal Processing Facility
ETR	Eastern Test Range

F	Fahrenheit
FAA	Federal Aviation Administration
F&D	Fill & Drain
FEP	Front End Processor
FLT	Flight

FMEA/CIL	Failures Modes & Effects Analysis/Critical Items List
FRF	Flight Readiness Firing
FRSC	Forward Reaction Control System
ft	Feet
FSS	Fixed Service Structure
FWD	Forward
FY	Fiscal Year

G&A	General and Administrative
G,g	Acceleration of Gravity
GAL	Gallons
GDSS(GD)	General Dynamics Space Systems
GEN	Generator
GFE	Government Furnished Equipment
GH2	Gaseous Hydrogen
GHe	Gaseous Helium
GLOW	Gross Liftoff Weight
GLS	Ground Launch Sequencer
GN2	Gaseous Nitrogen
GN&C	Guidance, Navigation & Control
GOAL	Ground Operations Aerospace Language
GOX	Gaseous Oxygen
GOCM	Ground Operations Cost Model
GPC	General Purpose Computer
GPM	Gallons Per Minute
GRD	Ground
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
GTSI	Grumman Technical Services, Inc.
GUCP	Ground Umbilical Carrier Plate

H2	Hydrogen
HAZGAS	Hazardous Gas
HB	High Bay
HDP	Holddown Post
He	Helium
HIM	Hardware Interface Module
HMF	Hypergolics Maintenance Facility
HPF	Horizontal Processing Facility
HQ	Headquarters
HVAC	Heating, Ventilation, and Air Conditioning
HW	Hardware
HYD	Hydraulic(s)
HYPER	Hypergolic
Hz	Hertz

IBM	International Business Machines
ICD	Interface Control Document
I/F	Interface
ILC	Initial Launch Capability
INST	Instrumentation
INTEG	Integration
IOC	Initial Operational Capability
IPR	Interum Problem Report
IRD	Interface Requirements Document
IUS	Interial Upper Stage

JSC	Johnson Space Center

K	Thousands
	Kelvin
KLB	Thousands of Pounds
KSC	Kennedy Space Center
KW	Kilowatt
LAC	Launch Accessories Contractor
LC-39	Launch Complex 39
LCC	Life Cycle Cost
	Launch Control Center
LCH4	Liquid Methane
LESC	Lockheed Engineering and Science Company
LETF	Launch Equipment Test Facility
LEO	Low Earth Orbit
LH2	Liquid Hydrogen
Li	Lithium
LN2	Liquid Nitrogen
LNG	Liquid Natural Gas
LO2	Liquid Oxygen
LOX	Liquid Oxygen
LPS	Launch Processing System
LRB	Liquid Rocket Booster
LRB-HPF	Liquid Rocket Booster Horizontal Processing Facility
LRBI	Liquid Rocket Booster Integration
LRU	Line Replaceable Unit
LSE	Launch Support Equipment
LSOC	Lockheed Space Operations Company
LUT	Launcher Umbilical Tower
MAX	Maximum
MECO	Main Engine Cutoff
MDAC	McDonnell Douglas Astronautics Company
MIL	Military

MIN	Minimum
MLP	Mobile Launch Platform
MMC	Martin-Marietta Corporation
MMH	Mono Methyl Hydrazine
MOD	Mission Operations Directorate
MOU	Memorandum of Understanding
MP	Manpower
MPS	Main Propulsion System
MSBLS	Microwave Scanning Beam Landing System
MSFC	Marshall Space Flight Center
MST	Mobile Service Tower
MTI	MortonThiokol, Inc.

N2	Nitrogen
NASA	National Aeronautics and Space Administration
NDE	Non-Destructive Evaluation
NDT	Non-Destructive Test
NF	Nose Fairing
N2O2	Nitrogen Tetroxide
NPL	Nominal Power Level
NPSH	Not positive Suction Head
NRC	National Research Council
NSTL	National Space Technology Laboratories (Stennis Space Center)
NSTS	National Space Transportation System
NWS	National Weather Service

OAA	Orbiter Access Arm
OIS	Operational Intercommunications System
OJT	On-the-job Training
O&M	Operations and Maintenance
OMD	Operating and Maintenance Documentation

OMI	Operations and Maintenance Instruction
OMRF	Orbiter Maintenance and Refurbishment Facility
OMRSD	Operational Maintenance Requirements and Specifications Document
OMS	Orbital Maneuvering System
OPF	Orbiter Processing Facility
OPS	Operations
OMBUU	Orbiter Mid Body Umbilical Unit
ORB	Orbiter
ORD	Operational Readiness Date
ORI	Operational Readiness Inspection
OSHA	Occupational Safety & Health Administration
OTV	Operational Television

PA	Public Affairs
PAWS	Pan Am World Services, Inc.
P/A	Propulsion/Avionics Module
Pc	Engine Combustion Chamber Pressure
PC	Personal Computer
PCM	Pulse Code Modulator
PCR	Payload Changeout Room
PDR	Preliminary Design Review
PER	Preliminary Engineering Report
PGHM	Payload Ground Handling Mechanism
PIC	Pyro Initiator Controller
PIF	Payload Integration Facility
P/L	Payload
PMM	Program Model Number
PMS	Permanent Measuring System
PO	Purchase Order
POP	Programs Operations Plan
PR	Problem Report
PRACA	Problem Reporting and Corrective Action
PRCBD	Program Review Control Board Directive

PRC	Planning Research Corporation
PRD	Program Requirements Document
PRESS	Pressure, pressurization
PROP	Propellant
PRR	Preliminary Requirements Review
PSI	Pounds Per Square Inch
psia	Pounds Per Square Inch Absolute
psig	Pounds Per Square Inch Gage
PSP	Process Support Plan
PT&I	Payroll Taxes and Insurance
P&W	Pratt & Whitney Company

Q	Dynamic Pressure
QA	Quality Assurance
Q-Alpha	Dynamic Pressure x Angle of Attack
QC	Quality Control
QD	Quick Disconnect
QTY	Quantity

R	Ranking
RAM	Random Access Memory
RCS	Reaction Control System
R&D	Research and Development
RF	Radio Frequency
RFP	Request for Proposal
RIC	Rockwell International Corporation
ROM	Rough Order of Magnitute
RP-1	Propellant (Kerosene Related Petroleum Product)
RPL	Rated Power Level
RPS	Record and Playback System
RPSF	Rotation, Processing & Surge Facility

R/R	Remove/Replace
RSLS	Redundant Set Launch Sequencer
RSS	Rotating Service Structure
R&T	Research and Technology
RTLS	Return to Launch Site

SAIL	Shuttle Avionics Integration Laboratory
SAB	Shuttle Assembly Building
SCAPE	Self-Contained Atmospheric Protective Ensemble
SDI	Strategic Defense Initiative
SDV	Shuttle Derivative Vehicle
SEB	Source Evaluation Board
SEC	Second(s), Secondary
SGOS	Shuttle Ground Operations Simulator
SIES	Supervision, Inspection & Engineering Services
SIT	Shuttle Integrated Test
	System Integrated Test
SLC-6	Shuttle Launch Complex No.6
SLF	Shuttle Landing Facility
SOFI	Spray On Foam Insulation
SOW	Statement of Work
SPC	Shuttle Processing Contractor
SPF	Software Production Facility
SPDMS	Shuttle Processing Data Management System
SRB	Solid Rocket Booster
SRM	Solid Rocket Motor
SRSS	Shuttle Range Safety System
SR&QA	Safety, Reliability and Quality Assurance
SSC	Stennis Space Center (NSTL)
SSME	Space Shuttle Main Engine
SSV	Space Shuttle Vehicle
STD	Standard
STS	Space Transportation System

SUBSTA	Substation
SW	Switch
S/W	Software

TAL	Transatlantic Landing
TBD	To Be Determined
T&C/O	Test and Checkout
TFER	Transfer
T-0	Liftoff Time
TOPS	Technical Operating Procedures
TPS	Thermal Protection System
TSM	Tail Service Mast
TTV	Termination/Test/Verification
TVA	Thrust Vector Activator
TVC	Thrust Vector Control
T/W	Thrust to Weight Ratio
TYP	Typical

ULCE	Unified Life Cycle Engineering
UMB	Umbilical
UPS	Unintegrated Power System
USAF	United States Air Force
USS	Utility Substation

V	Volt(s)
VAB	Vehicle Assembly Building
VAFB	Vandenberg Air Force Base
VIB	Vertical Integration Building
VLS	Vandenberg Launch Site
VPF	Vertical Processing Facility

WAD	Work Authorization Document
WBS	Work Breakdown Structure
WIP	Work in Progress
WSMR	White Sands Missile Range
WTR	Western Test Range

VOLUME IV

REVIEWS AND PRESENTATIONS

VOLUME IV

SECTION 1

INTEGRATED WORKING GROUP MEETING

December 16, 1987

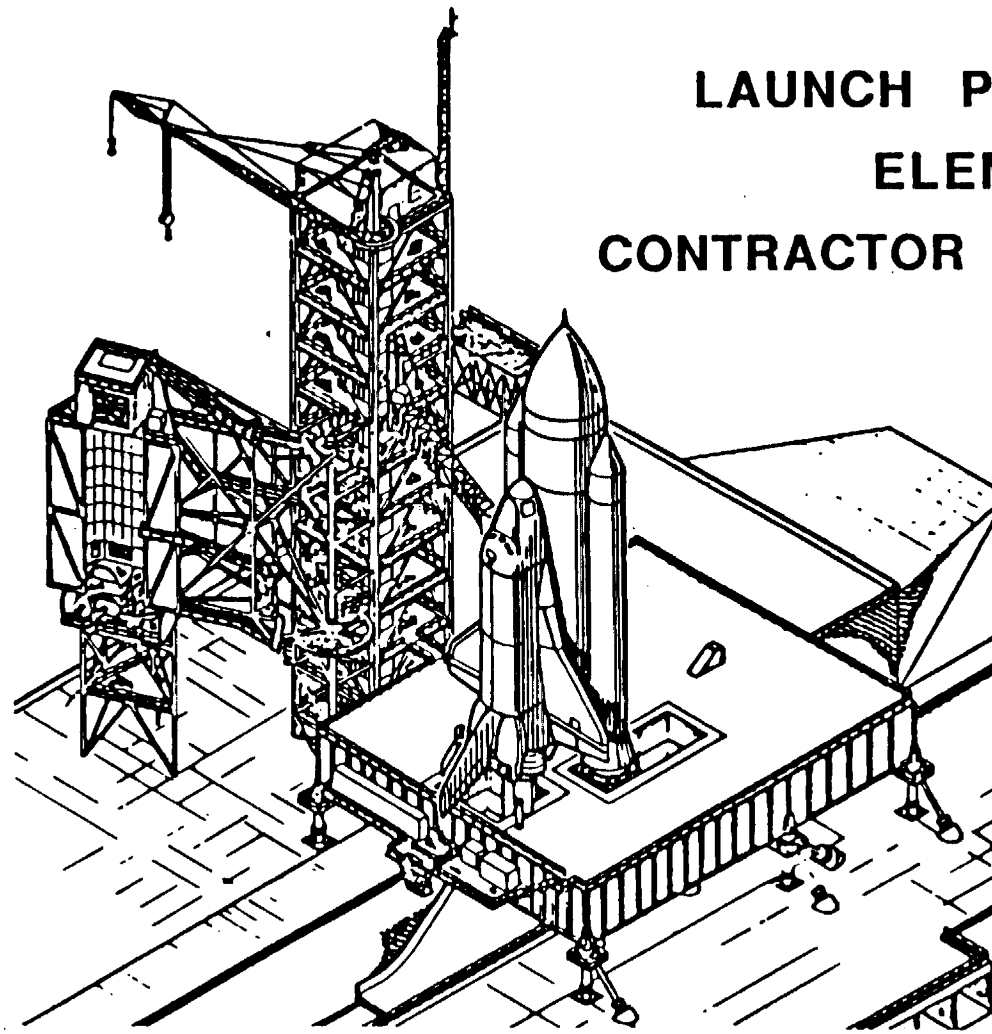
81005-01BM24

1A

K S C ADVANCED PROJECTS & TECHNOLOGY OFFICE

LIQUID ROCKET BOOSTER (LRB) INTEGRATION STUDY

DEC. 16, 1987
G. ARTLEY



LAUNCH PROCESSING ELEMENT CONTRACTOR INTRODUCTION

71210-01COVER

Lockheed Space Operations Company

LIQUID ROCKET BOOSTER (LRB) INTEGRATION STUDY

DEC. 16, 1987
G. ARTLEY

OBJECTIVES

- LAUNCH SITE OPERATIONS AND FACILITY IMPACTS
- PRELIMINARY OPERATIONAL SCENARIOS
- DESIGN RECOMMENDATIONS
- OPERATIONALLY EFFICIENT LRB SYSTEM
- LAUNCH SUPPORT SYSTEM DEFINITION/GSE AND ASSOCIATED COST
- LAUNCH SITE SUPPORT PLAN

LIQUID ROCKET BOOSTER (LRB) INTEGRATION STUDY

DEC. 16, 1987
G. ARTLEY

SCOPE

- DEPTH OF ANALYSIS TO FACILITATE CONFIGURATION COMPARISON
  - -STRENGTHS AND WEAKNESSES
    - OPERATIONAL
    - COST
    - ENVIRONMENTAL
- SPECIFIC DESIGN RECOMMENDATIONS
- ALL PHASES OF LAUNCH SITE PROCESSING
- IDENTIFY DESIGN ENHANCEMENTS
  - -OPERATIONS
  - -LIFE CYCLE COST
- PLAN DETAIL CONSISTENT WITH MSFC PHASE A STUDY
- OPERATIONAL CONCERNS

-SAFETY	-MANPOWER
-FACILITIES	-STS OPS
-SYSTEMS	-SCHEDULE
-PROCEDURES	-COSTS

LIQUID ROCKET BOOSTER (LRB) INTEGRATION STUDY

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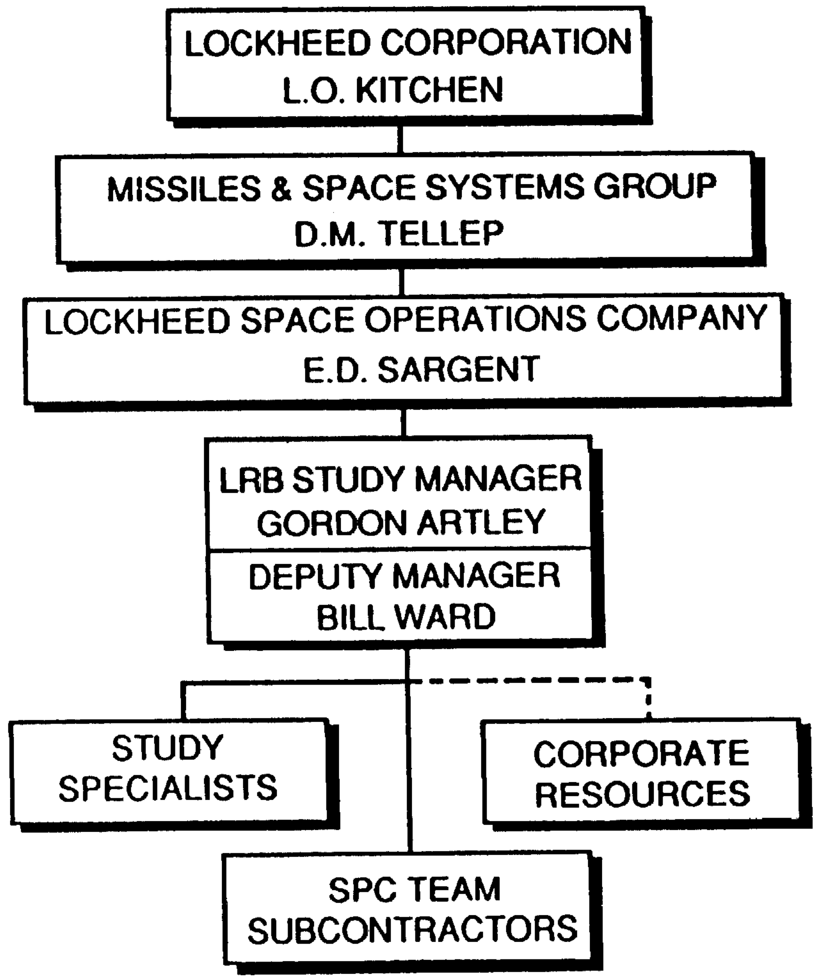

Administrative Organization

LIQUID ROCKET BOOSTER (LRB) INTEGRATION STUDY

DEC. 16, 1987
G. ARTLEY

LSOC LRB STUDY MANAGER
GORDON ARTLEY

- SINGLE POINT-OF-CONTACT
- CUSTOMER INTERFACE
- LOCKHEED CORPORATE INTERFACE
- SPC INTERFACE
- OPTION RECOMMENDATIONS
- FINAL REPORT

LSOC LRB STUDY DEPUTY MANAGER
WILLIAM K. WARD

- ALTERNATE FOR STUDY MANAGER
- SPC SUPPORT COORDINATION
- IMPACT ANALYSIS

PROCESS ENGINEERING SPECIALIST
L. PAT SCOTT

PRIMARY
- COMPILE BASELINE
- LRB REQUIREMENTS
- LRB SCENARIOS

DESIGN ENGINEERING SPECIALIST
GREGORY A. DE BLASIO

PRIMARY
- IMPACT ANALYSIS
- DESIGN RECOMMEN-DATIONS

OPERATIONS PROCESSING SPEC
R KEITH HUMPHRYES

PRIMARY
- LAUNCH SITE PLANS
- FOLLOW-ON RECOMMENDATIONS
- FINAL REPORT

SAFETY, MAINT & LIFE CYCLE COST SPEC
GERALD S. LE FEBVRE

SUPPORT
- DESIGN RECOMMENDA-TIONS
- LAUNCH SITE PLANS
- ENVIROMENTAL CONCERNS

ENTRY POINT SPC WORKING LEVEL INTERFACES WITH SPC MATRIX SPECIALISTS

- **SHUTTLE DATA SYSTEMS**
  J.W. ENTINGER
- **OPERATIONS CONTROL**
  G.L. CRAWFORD
- **SHUTTLE & GROUND SUPPORT ENGINEERING**
  T.J. HARTSELLE
- **SHOPS & PROCESSING SUBCONTRACTORS**
  H.C. BYRD
- **SUPPORT OPERATIONS**
  A.S. RUSSELL
- **LOGISTICS**
  D.T. GREGORY
- **SAFETY ENVIRONMENT**
  R. LEE
- **RELIABILITY, MAINTAINABILITY & QUALITY ASSURANCE**
  C.A. BLUE
- **VANDENBERG LAUNCH SITE OPERATIONS**
  K. GEILER

KSC ADVANCED PROJECTS & TECHNOLOGY OFFICE

LIQUID ROCKET BOOSTER (LRB) INTEGRATION STUDY

DEC. 16, 1987
G. ARTLEY

SPC TECHNICAL EXPERTISE / **LRB STUDY ISSUES**

LRB study issues (columns):
1. LIQUID PROPELLANT AQUISITION, STORAGE AND HANDLING
2. LRB PHYSICAL PLANT, LOCATION, & RESTRICTIONS
3. LRB UNIQUE HAZARDS
4. LRB GROUND TESTING/PROCESSING
5. LRB GROUND/LAUNCH OPERATIONS
6. VEHICLE/ET MODIFICATIONS
7. VEHICLE OPERATION & MAINT
8. GROUND SUPPORT EQUIP MODS
9. COMMON/SHARED STS/LRB GROUND SUPPORT EQUIPMENT
10. AUTOMATED (LPS) GROUND/LAUNCH OPERATIONS
11. AUTOMATION & OTHER PROCESSING ENHANCEMENTS
12. LRB UNIQUE SPARES
13. COMMON/SHARED STS/LRB SPARES

SPC TECHNICAL EXPERTISE	1	2	3	4	5	6	7	8	9	10	11	12	13
SHUTTLE DATA SYSTEMS (J.W. ENTINGER)													
• LAUNCH PROCESSING SYSTEM ENGINEERING				●	●			●	●	●	●		
• LAUNCH PROCESSING SYSTEM SOFTWARE					●			●	●	●	●		
• SHUTTLE PROCESSING DATA MANAGEMENT				●	●	●	●	●	●		●	●	●
OPERATIONS CONTROL (G.L. CRAWFORD)													
• LAUNCH CONTROL COMPLEX TEST OPS	●		●	●	●		●			●	●		
• FLOW PROCESS PLANNING & CONTROL	●	●	●	●	●	●	●	●	●				
SHUTTLE & GROUND SUPPORT ENGINEERING (T.J. HARTSELLE)													
• PROJECT ENGR & TEST INTEGRATION		●	●	●	●	●		●	●	●			
• ORBITER AVIONICS/MECH/ELEC SYS ENGR				●	●	●	●	●	●	●	●	●	●
• FLUID/CRYOGENIC/PAD/MECH SYS ENGR	●	●	●	●	●	●	●	●	●	●	●	●	●
• GSE/FACILITY SYSTEMS ENGINEERING	●	●	●	●	●	●	●	●	●	●	●	●	●
• GROUND SYSTEMS DESIGN ENGR	●	●	●	●	●	●	●	●	●	●	●	●	●
SHOPS & PROCESSING SUBCONTRACTORS (H.C. BYRD)													
• ORBITER PROCESSING FACILITY OPS	●	●	●	●	●		●						
• INDUSTRIAL SHOPS & LABS	●	●											
• THERMAL PROTECTION SYSTEM OPS				●	●	●	●						
• OPERATIONS ANALYSIS (PAN AM)	●	●	●	●	●	●	●	●	●	●	●	●	●
• ROCKETDYNE OPS (ROCKETDYNE)	●	●	●	●	●	●	●	●	●	●	●	●	●
• VAB OPERATIONS	●	●	●	●	●								
• PAD/MLP OPERATIONS	●	●		●	●		●	●	●			●	●
• OFFSITE & CONTINGENCY LANDING OPS	●		●	●	●		●	●	●				
SUPPORT OPERATIONS (A.S. RUSSELL)													
• INTEGRATED GROUND OPS (GTSI)				●	●		●	●	●	●	●		
• FACILITY OPERATIONS & MAINTENANCE	●	●	●	●	●			●	●				
• COMMUNICATIONS					●		●	●	●	●	●		
LOGISTICS (D.T. GREGORY)													
• LOGISTICS OPERATIONS	●					●		●	●			●	●
• LOGISTICS SUPPORT	●					●		●	●			●	●
• TECHNICAL TRAINING	●	●	●	●	●	●	●	●	●	●	●	●	●
SAFETY AND ENVIROMENT (R. LEE)													
• SAFETY ENGINEERING	●	●	●	●	●	●	●	●					
• SAFETY OPERATIONS	●	●	●	●	●	●	●	●					
RELIABILITY, MAINTAINABILITY & QUALITY ASSURANCE (C.A. BLUE)													
• RELIABILITY MAINT & QA ENGR	●		●	●	●	●	●	●	●	●			
• QUALITY CONTROL	●	●	●	●	●	●	●	●	●	●	●	●	●
VANDENBERG LAUNCH SITE OPERATIONS (K. GEILER)													
• VLS ENGINEERING	●	●	●	●	●	●	●	●	●	●	●	●	●
• VLS ET/SRB OPERATIONS		●	●	●	●	●	●	●	●	●	●	●	●
• VLS TECHNICAL SUPPORT (GTSI)			●	●	●	●	●	●	●	●	●	●	●
• VLS FACILITIES	●	●	●	●	●			●	●				

Expertise/Issue Matrix

71210-01C

Lockheed Space Operations Company

LIQUID ROCKET BOOSTER (LRB) INTEGRATION STUDY

DEC. 16, 1987
G. ARTLEY

LOCKHEED SPACE OPERATIONS CO.

- STS PROCESSING / LAUNCH OPERATIONS / FACILITIES / PLANNING / ENGINEERING / LOGISTICS
- CONTRACTOR TEAM MANAGEMENT / INTEGRATION
- LAUNCH SITE FACILITY ACTIVATION / SUPPORT (PAD B / MLP 3 / RPSF / OMRF / VLS)
- GSE / LSE DESIGN / MOD MAINTENANCE AND SUSTAINING ENGINEERING
- PROPELLANT HANDLING / TESTING / LAUNCH OPERATIONS
- LPS SYSTEM SOFTWARE DEVELOPMENT/ MAINTENANCE
- DATA MANAGEMENT SYSTEM SOFTWARE
- COMMUNICATION SYSTEM DESIGN / DEVELOPMENT
- QUALITY / SAFETY / RELIABILITY ANALYSIS

LOCKHEED CORPORATE

- LEMSCO - LAS VEGAS ENVIRONMENTAL STUDIES
- LEMSCO - WHITE SANDS
  - REACTION CONTROL SYSTEM TESTS
  - CRYOGENIC PUMP / VALVE COMPONENT TEST
  - FLAMMABILITY STUDIES / TESTS
- LOCKHEED - HUNTSVILLE
  - SSME STRUCTURAL / THERMAL ANALYSES
  - SRB STRUCTURAL / GAS DYNAMIC MODELS / DESIGN SUPPORT
  - MSFC STUDY COORDINATION

GRUMMAN TECHNICAL SERVICES

- LCC COMPUTER / ELECTRONIC SYSTEMS OPERATIONS AND MAINTENANCE
- INSTRUMENTATION AND MEASUREMENT SUPPORT OF ALL LPS SYSTEMS
- SPECIALIZED DIAGNOSTIC SYSTEM DEVELOPMENT
- TELEMETRY / GROUND STATION OPERATIONS AND MAINTENANCE

PAN AM

- OPERATIONS ANALYSIS / PROCESSING ENHANCEMENTS
- RELIABILITY CENTERED MAINTENANCE PROGRAMS
- STS GROUND PROCESSING EFFICIENCY STUDIES
- RELIABILITY CONTROL PROGRAMS
- LOGISTICS SUPPORT ANALYSIS
- AUTOMATED WORK CONTROL
- GSE / LSE AVAILABILITY STUDIES

ROCKETDYNE

- SSME DESIGN / DEVELOPMENT / TESTING
- MAIN ENGINE PERFORMANCE UPGRADE / ENHANCEMENTS
- ADVANCED ENGINE DEVELOPMENT / LIFE CYCLE STUDIES
- LARGE EXPENDABLE LIQUID BOOSTER ENGINES
- NSTL / KSC ENGINE STATIC FIRING / FLIGHT CERTIFICATION
- PROPULSION / VEHICLE INTEGRATION / FLIGHT SOFTWARE / LAUNCH OPERATIONS

Lockheed / SPC Team Capabilities

LIQUID ROCKET BOOSTER (LRB) INTEGRATION STUDY

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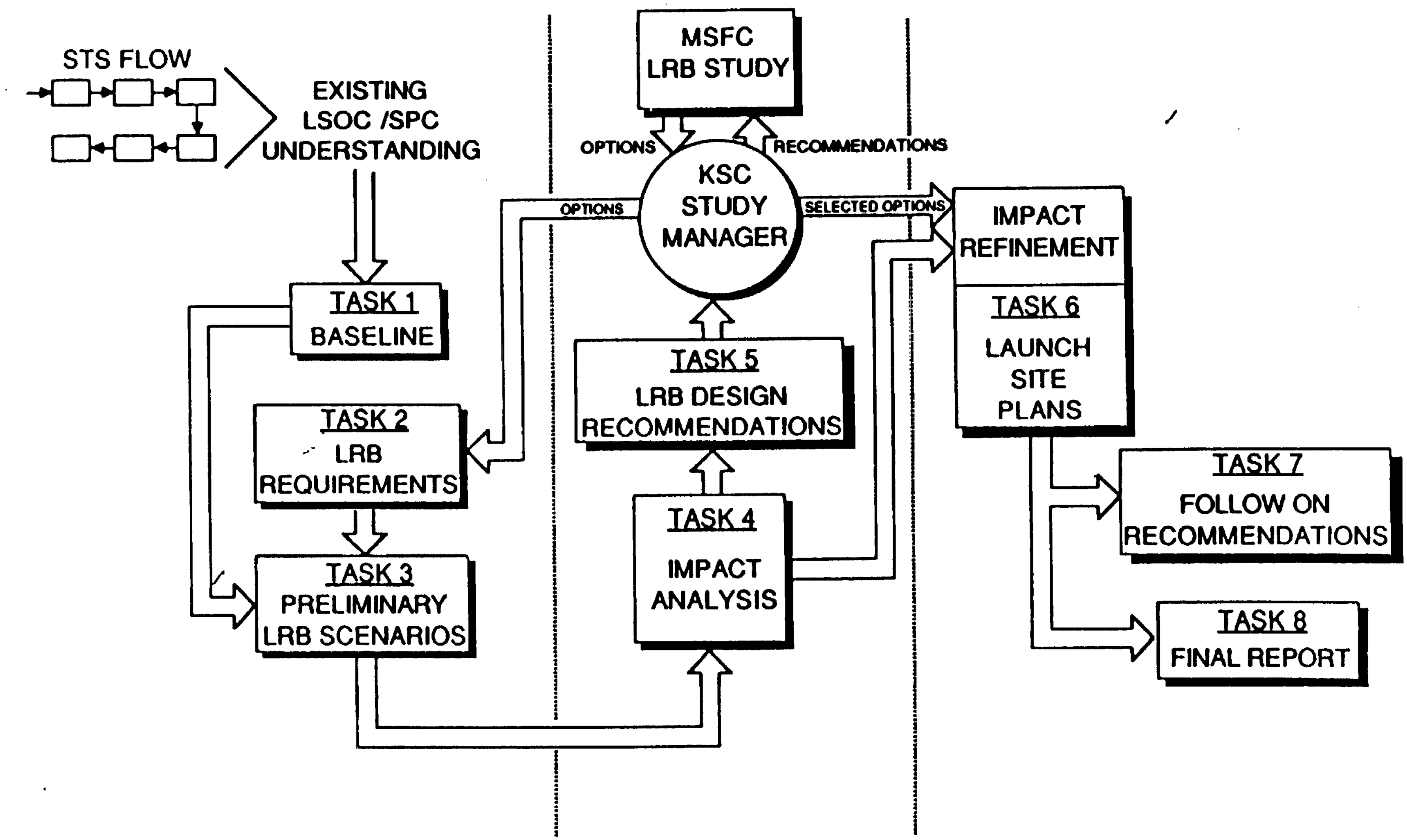

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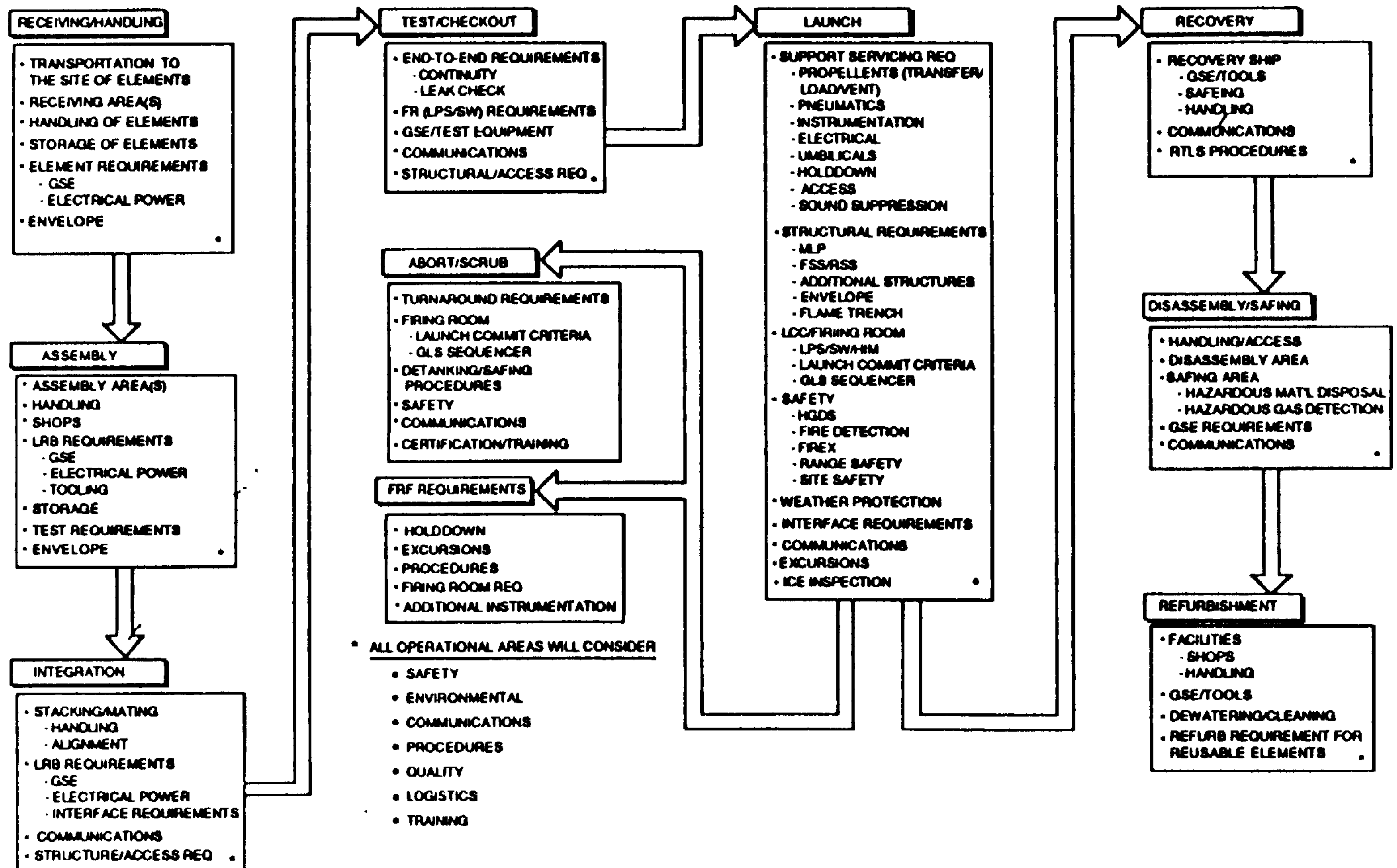

LRB Configuration Evaluation Areas of Impact

71210-01E

Lockheed Space Operations Company

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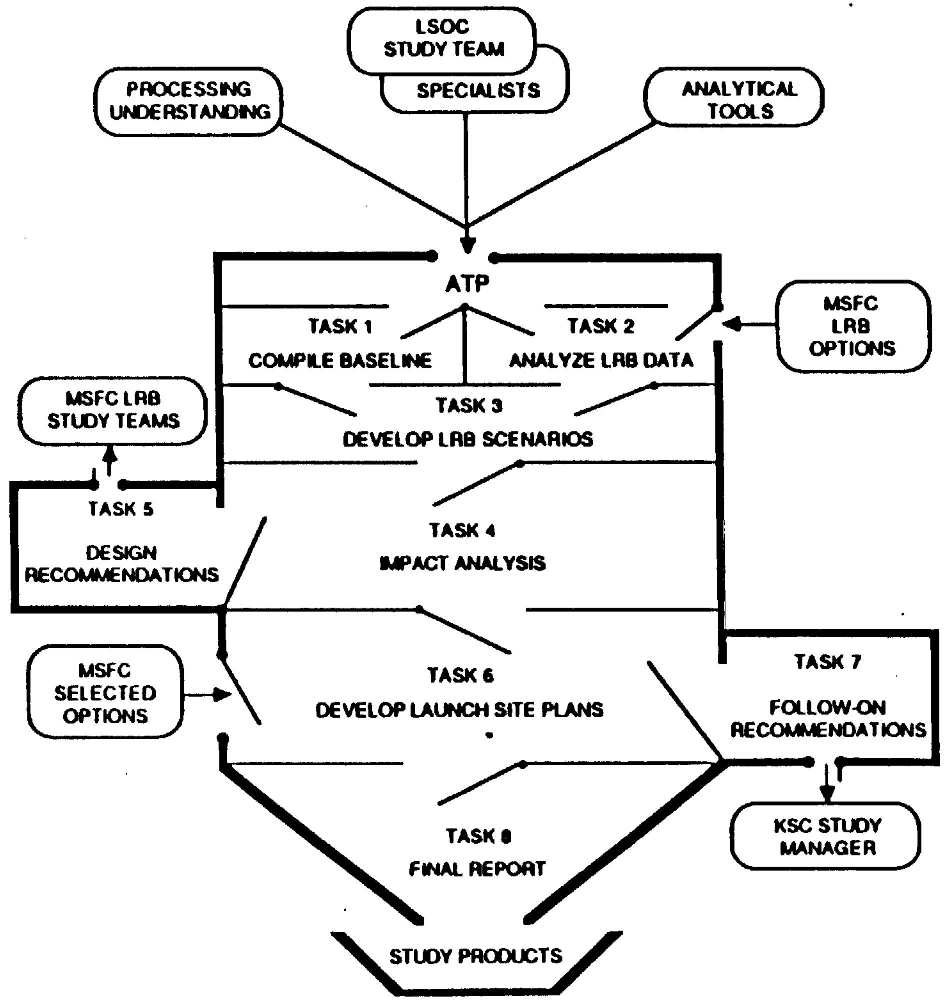


Study Task Interrelationships

LIQUID ROCKET BOOSTER (LRB) INTEGRATION STUDY

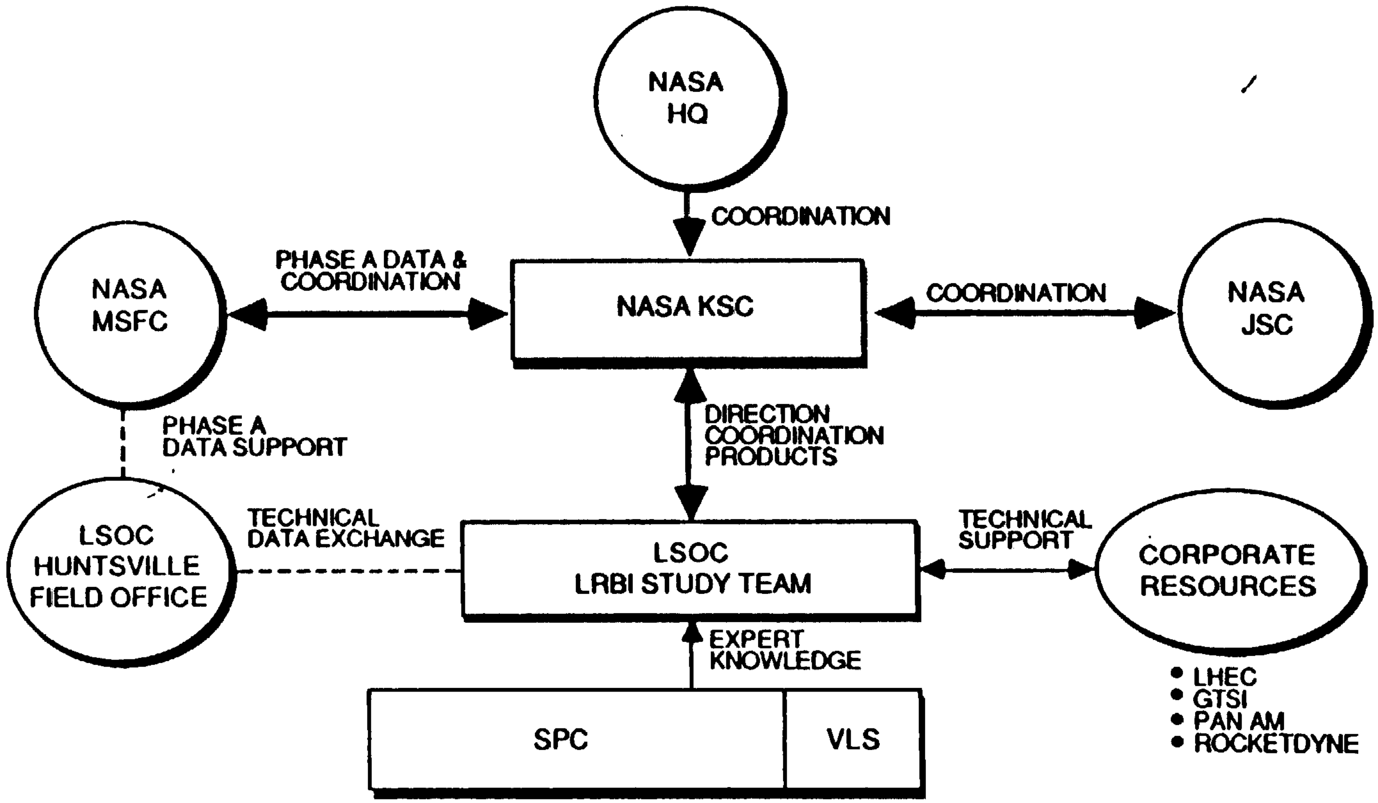
DEC. 16, 1987
G. ARTLEY

STUDY PRODUCTS

- LRB GROUND OPERATIONS PLAN.
- LRB PROCESSING TIMELINE ASSESSMENTS.
- LRB FACILITY REQUIREMENTS AND CONCEPTS FOR NEW FACILITIES.
- LRB LAUNCH SUPPORT EQUIPMENT DEFINITION.
- LRB GROUND SUPPORT EQUIPMENT DEFINITION.
- LRB MANPOWER.
- COST ESTIMATES INCLUDING TRANSITION.
- POTENTIAL IMPACTS TO ON-GOING LAUNCH SITE ACTIVITY.
- PRELIMINARY TRANSITION PLAN.
- POTENTIAL ENVIRONMENTAL AND SAFETY IMPLICATIONS.
- PROPELLANT ACQUISITION STORAGE AND HANDLING REQUIREMENTS.
- RECOMMENDED CHANGES TO LRB DESIGN FOR OPERATIONAL EFFICIENCY.
- RECOMMENDATIONS FOR FOLLOW-ON STUDY ACTIVITY.

LIQUID ROCKET BOOSTER (LRB) INTEGRATION STUDY

DEC. 16, 1987
G. ARTLEY

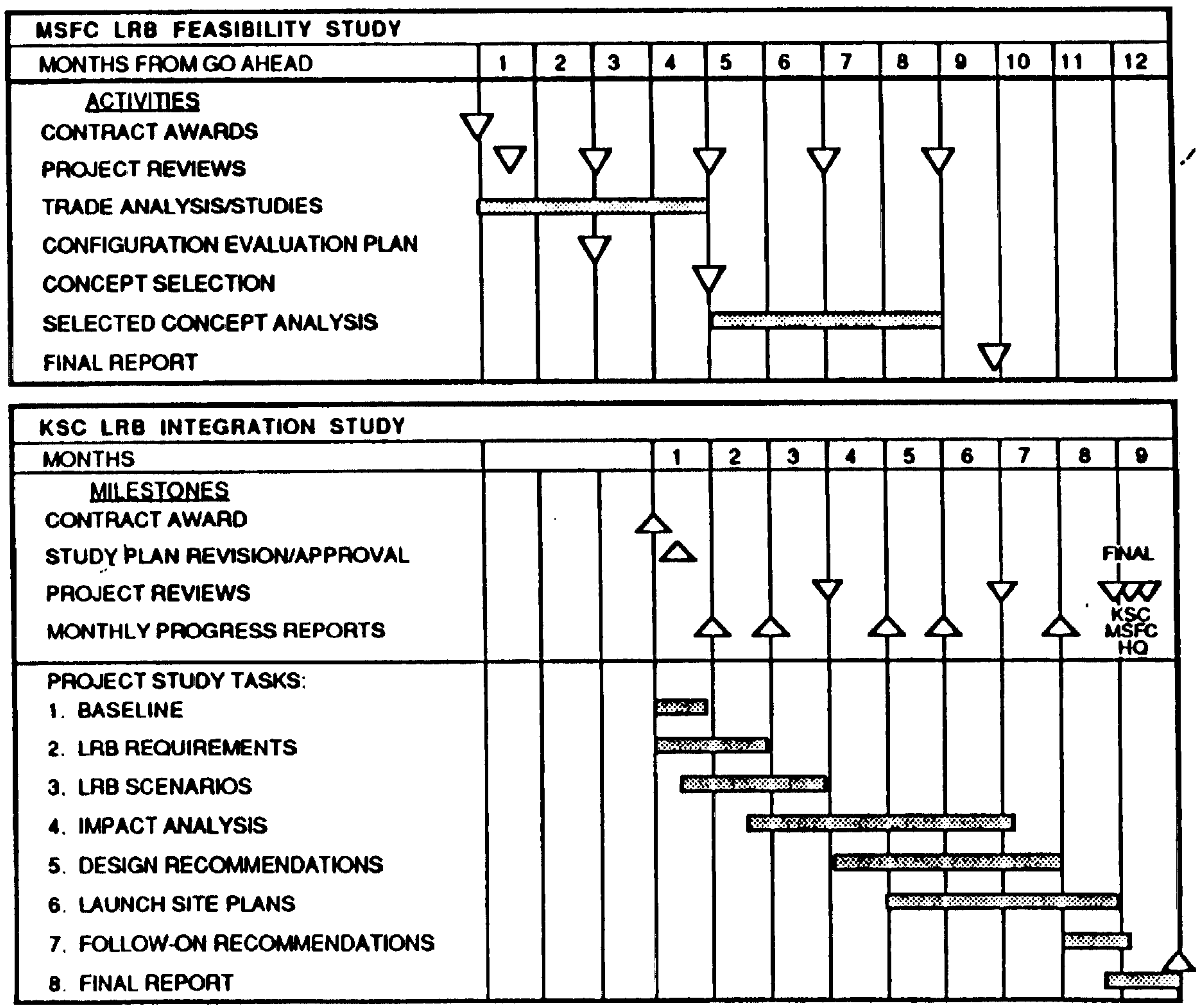


Program Interface Definition

KSC ADVANCED PROJECTS & TECHNOLOGY OFFICE

LIQUID ROCKET BOOSTER (LRB) INTEGRATION STUDY

DEC. 16, 1987
G. ARTLEY



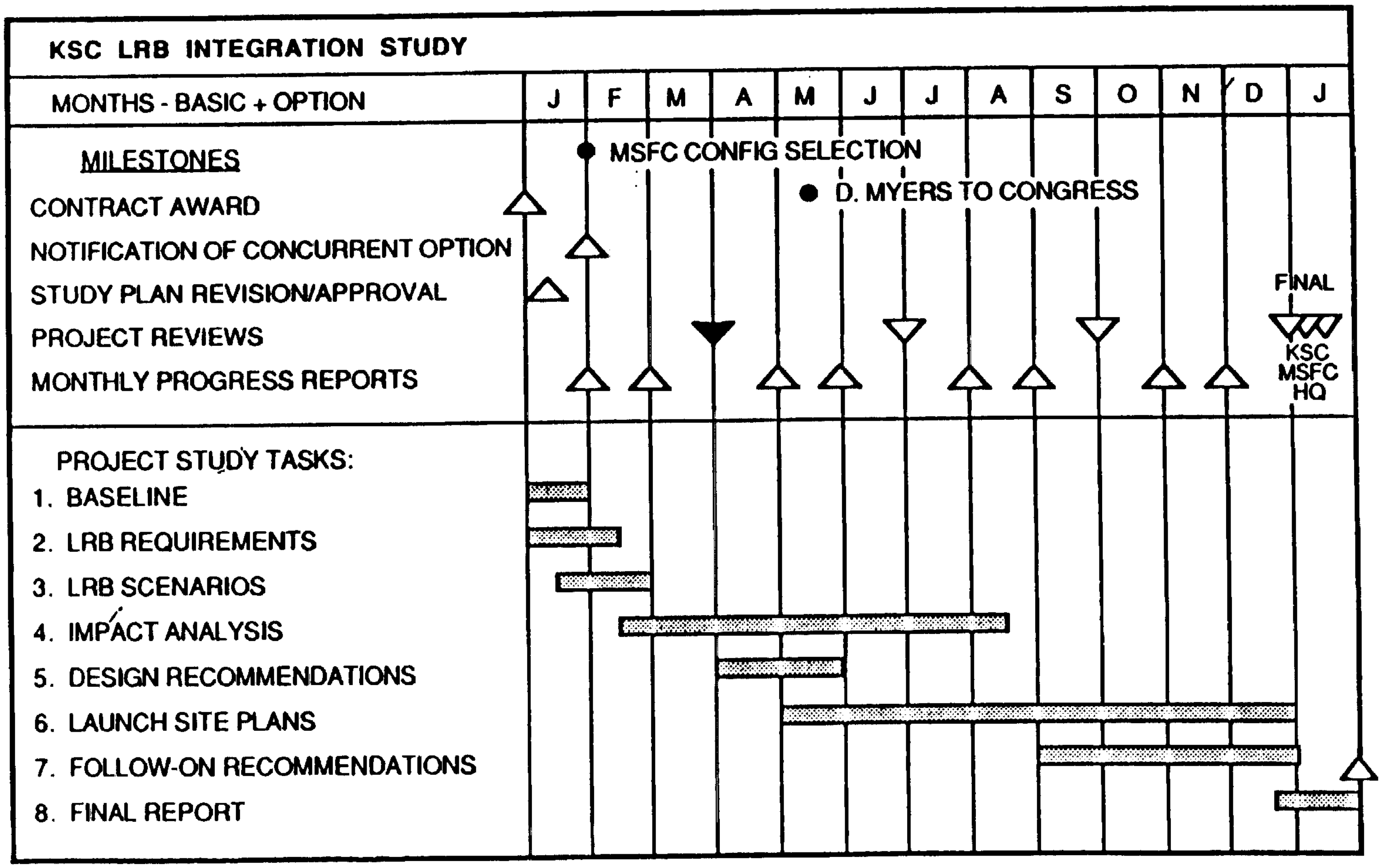
LRB Integration and LRB Feasibility Schedule Relationship

71210-01G

Lockheed Space Operations Company

LIQUID ROCKET BOOSTER (LRB) INTEGRATION STUDY

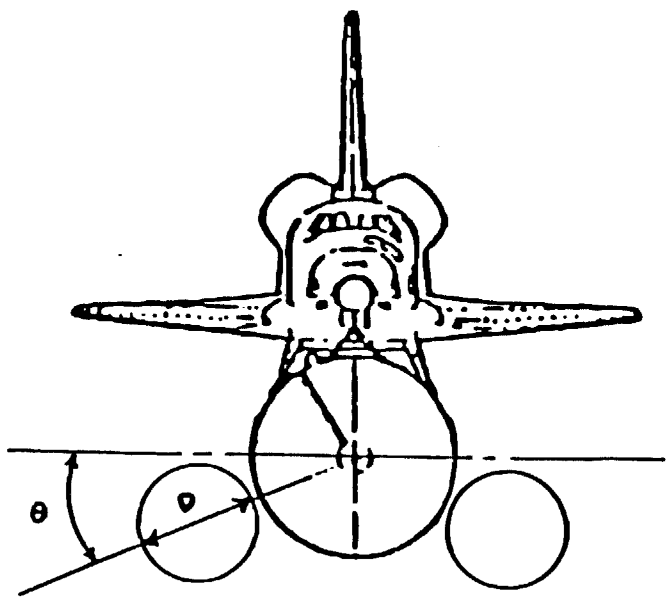
DEC. 16, 1987
G. ARTLEY



ORGANIZATION: ED35	MARSHALL SPACE FLIGHT CENTER	NAME: ALONZO FROST
CHART NO.: 1	ALTERNATE LRB TEST PLAN	DATE: 12 - 15 - 87

- MSFC 14 x 14 Inch Trisonic Wind Tunnel
- .004 - scale SSLV model
- Instrumentation - 6 component balance (mated vehicle)
3 component balance (orbiter right wing)
1 component balance (each left elevon)
9 base pressures
- Mach number range - 0.6 to 4.45
- Sector angle range - -10 to +10 deg (2 deg increments)

ORGANIZATION: ED35	MARSHALL SPACE FLIGHT CENTER	NAME: ALONZO FROST
CHART NO.: 2	ALTERNATE LRB TEST PLAN	DATE: 12 - 15 - 87

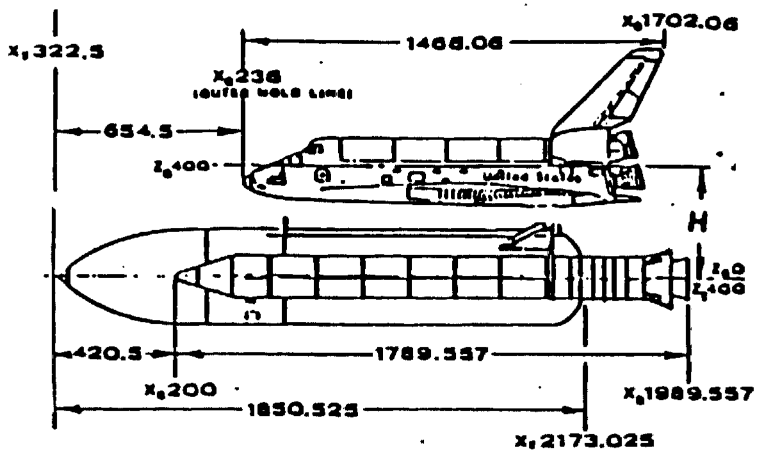


D = 15 ft.

θ = 3.6, 7, 10 deg

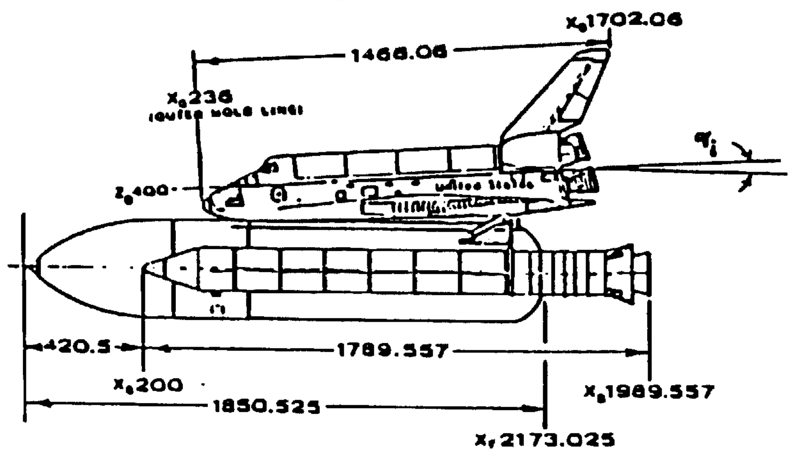
CONFIGURATION 1 - LRB Position Change

ORGANIZATION: ED35	MARSHALL SPACE FLIGHT CENTER	NAME: ALONZO FROST
CHART NO.: 3	ALTERNATE LRB TEST PLAN	DATE: 12 - 15 - 87



CONFIGURATION 2 - Orbiter Height

$\Delta H = +2, +3$ ft.



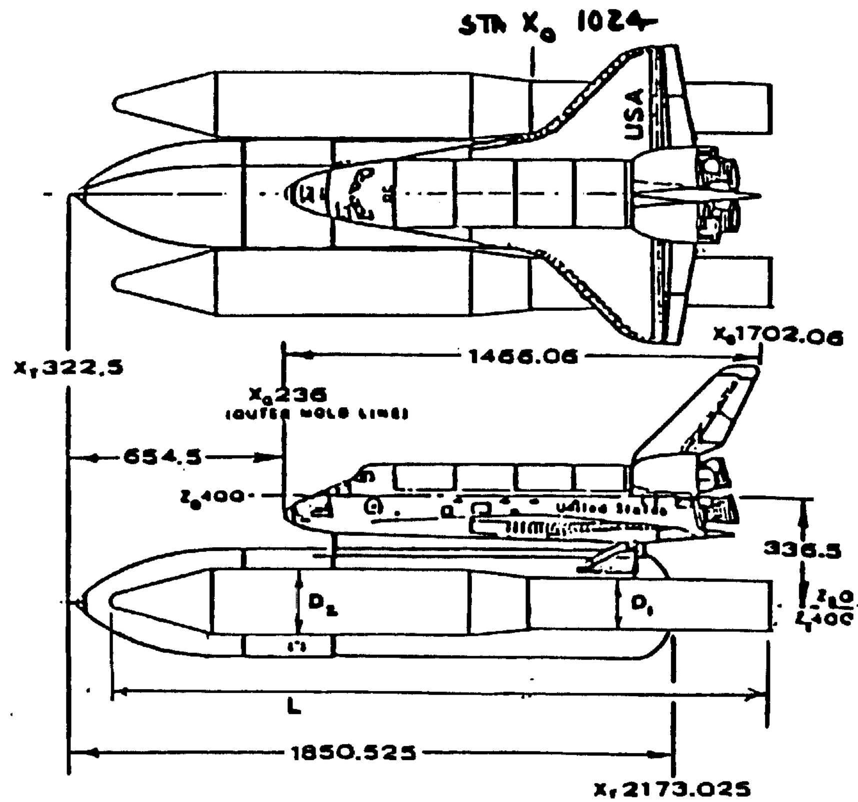
CONFIGURATION 3 - Orbiter Incidence

$\Delta\alpha_i = -1, -2, -3$ deg

MSFC - Form 3304 (Rev. January 1981)

FILE NO.

ORGANIZATION: ED35	MARSHALL SPACE FLIGHT CENTER	NAME: ALONZO FROST
CHART NO.: 4	ALTERNATE LRB TEST PLAN	DATE: 12 - 15 - 87



$D_1 = 12.2$ ft.

$D_2 = 15, 18$ ft.

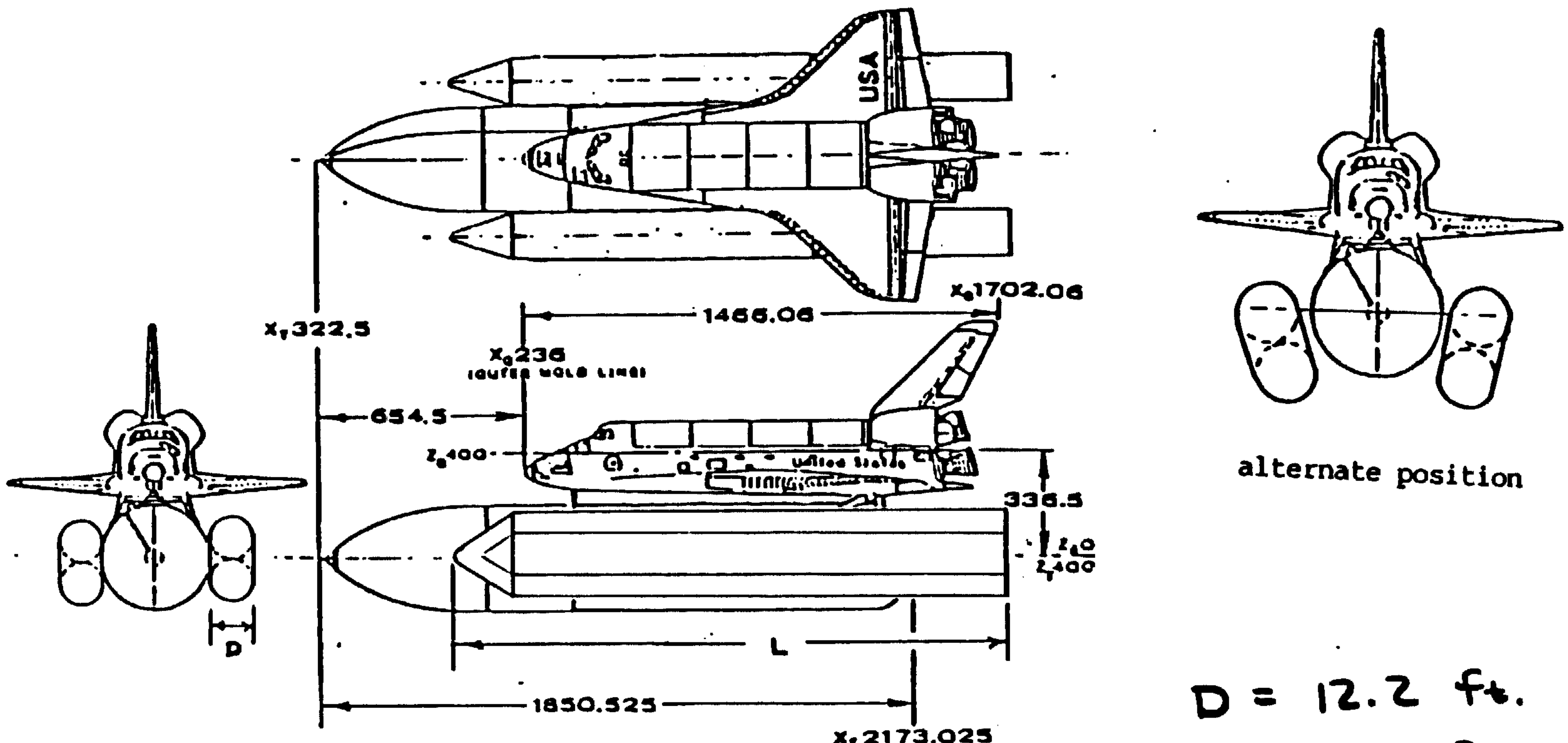
$L = 159$ ft.

CONFIGURATION 4 - Multi-Diameter LRB

MSFC - Form 3304 (Rev. January 1981)

FILE NO.

ORGANIZATION	MARSHALL SPACE FLIGHT CENTER	NAME:
ED35	ALTERNATE LRB TEST PLAN	ALONZO FROST
CHART NO.:		DATE:
5		12 - 15 - 87



D = 12.2 ft.
L = 159 ft.

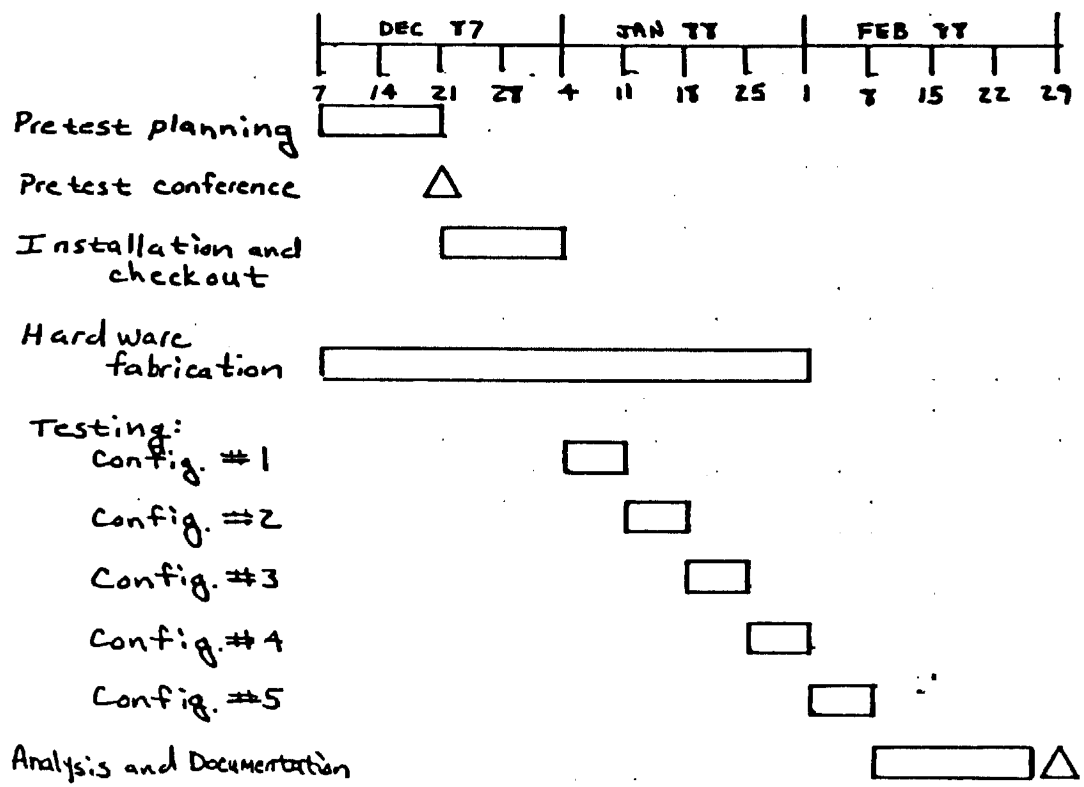
CONFIGURATION 5 - Twin Tank LRB

ORGANIZATION: ED35	MARSHALL SPACE FLIGHT CENTER	NAME: ALONZO FROST
CHART NO.: 6	ALTERNATE LRB TEST PLAN	DATE: 12 - 15 - 87

AERODYNAMIC TEST SCHEDULE

ALTERNATE LRB CONFIGURATIONS

TWT 711 - MSFC 14-INCH TRISONIC WIND TUNNEL



FILE NO.

	DESCRIPTION	WEIGHT LBS	CENTER OF GRAVITY - IN. X	Y	Z	MOMENTS/PRODUCTS OF INERTIA - SLUG*FEET*FEET IX	IY	IZ	PXY	PXZ	PYZ
!	OV 102/??	150811	1059.1	-0.7	365.7	803763	5050253	5394194	8499	80114	-841
	SAME ... INERT	20950	1495.0	0.3	384.3	24007	19615	17865	-24	-2522	190
	BUOYANCY	80	1114.0	-0.3	369.1	0	0	0	0	0	0
!	CREW MODULE	4361	502.6	-2.7	387.0	2601	4039	3182	46	461	201
!	ORBITER WITHOUT CONSUMABLES	176210	1097.2	-0.6	368.4	832085	6171524	6461160	11384	99608	-413
	NON-PROP CONSUM AT SRB IGN	5397	977.6	3.4	342.8	9648	126404	127666	-1365	14994	-446
	MPS PROPELLANT AT SRB IGN	5166	1404.5	6.8	352.7	4149	5527	5037	-1004	1041	-418
!	OMS FUEL LEFT	2967	1424.4	-71.4	498.1	204	239	249	4	-1	-9
!	OMS FUEL RIGHT	2967	1424.4	71.4	498.1	204	239	249	-4	-1	9
!	OMS OXIDIZER LEFT	4933	1423.6	-109.1	458.9	394	391	483	23	11	7
!	OMS OXIDIZER RIGHT	4933	1423.6	109.1	458.9	394	391	483	-23	11	-7
	RCS PROPELLANT - FWD	1950	317.8	5.4	365.2	220	0	220	0	0	0
	RCS PROPELLANT - AFT	4970	1345.3	0.0	470.3	8661	1022	9135	0	76	1
!	ORBITER MODULE TOTAL AT SRB IGN	209493	1124.9	-0.2	377.7	935179	7125708	7409318	9450	247689	1420
!	CARGO MODULE	68970	1156.3	0.9	306.2	24043	202606	202584	-6410	-4397	533
!	CARGO BUOYANCY	30	1156.3	0.9	306.2	0	0	0	0	0	0
!	CARGO MODULE TOTAL	69000	1156.3	0.9	306.2	24043	202606	202584	-6410	-4397	533
!	ORBITER PLUS CARGO AT SRB IGN	278493	1132.7	0.1	379.8	960044	7340116	7622910	3440	246273	780
	ET (LO2 AFT) AT MM 12/12/85	66623	1356.9	2.7	424.6	359006	3951635	3948632	3693	150466	7002
	ET BUOYANCY	175	1356.9	2.7	424.6	0	0	0	0	0	0
!	MPS FUEL AT SRB IGN	225638	1607.6	0.0	400.0	0	3771783	3771783	0	0	0
	MPS LOX AT SRB IGN	1367983	729.3	0.6	401.4	74408	4881974	4831970	136250	315710	26981
	MPS PRESSURANT	429	753.6	0.0	400.0	0	17697	17697	-12	-27	0
	ICE/FROST ... AIR+N2+GHe H2O	317	1352.6	2.6	424.5	0	0	0	0	0	0
	ET MODULE TOTAL AT SRB IGN	1665154	875.7	0.6	402.1	441294	40865648	48804400	132558	585345	34720
	SRB LEFT SEPARATION	186453	1802.6	-250.9	401.0	188161	11824861	11828475	-25231	8902	469
	SRB LEFT INERTIAL LOSSES	1116562	1696.8	-250.9	400.1	736224	35414985	35415330	1502	232	2
	SRB LEFT AT IGN. RSRML-400	1303015	1711.9	-250.6	400.2	924419	47626228	47630161	-25007	13542	456
	SRB RIGHT SEPARATION	186453	1802.6	250.9	401.0	188161	11824861	11828475	25231	8902	-469
	SRB RIGHT INERTIAL LOSSES	1116562	1696.8	250.5	400.1	736224	35414985	35415330	-1502	232	2
	SRB RIGHT AT IGN. RSRML-400	1303015	1711.9	250.6	400.2	924419	47626228	47630161	25007	13542	456
!	TOTAL MASS PROPERTIES AT SRB IGN	4549683	1415.8	0.2	420.2	44186717	423833358	354774949	21035	9180183	31514

SHUTTLE SYSTEM CG ... TO MECO = 442

ORBITER AND CARGO IN ORBITER COORDINATE SYSTEM. ET, SRB, AND SHUTTLE TOTAL IN SHUTTLE COORDINATE SYSTEM.

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VEHICLE SUMMARY WEIGHT STATEMENT

	DESCRIPTION	WEIGHT LBS	(CENTER OF GRAVITY-IN) X	Y	Z	(MOMENTS/PRODUCTS OF INERTIA - SLUG*FEET*FEET) IX	IY	IZ	PXY	PXZ	PYZ
I	OV-103(7)	150811	1059.1	-0.7	365.7	809763	5050253	5344194	8439	80114	-841
	SSME X 3 INERT	20958	1495.0	0.3	384.3	24007	19615	17865	-24	-2522	190
	BUOYANCY	80	1114.0	-0.3	368.1	0	0	0	0	0	0
I	CREW MODULE	4361	502.6	-2.7	387.0	2601	4039	3182	46	461	201
I	ORBITER WITHOUT CONSUMABLES	176210	1097.2	-0.6	368.4	832085	6171524	6461160	11384	99608	-419
	NON-PROP CONSUM AT SRB IGN	5397	977.6	3.4	342.8	9648	126404	127666	-1265	14994	-446
	MPS PROPELLANT AT SRB IGN	5466	1404.5	6.8	352.7	4149	5527	5037	-1004	1041	-416
I	OMS FUEL LEFT	2854	1425.0	-71.4	498.0	196	220	230	4	-1	-9
I	OMS FUEL RIGHT	2854	1425.0	71.4	498.0	196	220	230	-4	-1	9
I	OMS OXIDIZER LEFT	4746	1424.1	-109.1	458.8	382	359	452	23	10	7
I	OMS OXIDIZER RIGHT	4746	1424.1	109.1	458.8	382	359	452	-23	10	7
	RCS PROPELLANT - FWD	1950	317.8	5.4	365.2	220	0	220	0	0	0
	RCS PROPELLANT - AFT	4970	1345.9	0.0	470.3	8661	1022	9135	0	76	1
I	ORBITER MODULE TOTAL AT SRB IGN	208893	1124.2	-0.2	377.4	932639	7113987	7397596	9442	244066	-1423
I	CARGO MODULE	57970	1163.6	1.1	388.4	23894	271047	271868	-7644	-10769	[illegible]
I	CARGO BUOYANCY	30	1163.6	1.1	388.4	0	0	0	0	0	0
I	CARGO MODULE TOTAL	58000	1163.6	1.1	388.4	23894	271847	271868	-7644	10769	[illegible]
I	ORBITER PLUS CARGO AT SRB IGN	266893	1132.7	0.1	379.0	957731	7402276	7684742	2302	237542	[illegible]
	ET-02B ACT WT NMC 12/12/85	66623	1856.9	2.7	424.6	359006	3951695	3948632	3693	158466	2002
	ET BUOYANCY	175	1856.9	2.7	424.6	0	0	0	0	0	0
	MPS FUEL AT SRB IGN	229630	1607.6	0.0	400.0	0	3771783	3771783	0	0	0
	MPS LOX AT SRB IGN	1367983	729.3	0.6	401.4	74488	4881974	4831370	136250	915710	26481
	MPS PRESSURANT	429	753.6	0.0	400.0	0	17697	17692	[illegible]	[illegible]	0
	ICE/FROST/LIQ AIR+N2+TPS H2O	317	1852.6	2.6	424.5	0	0	0	0	0	0
	ET MODULE TOTAL AT SRB IGN	1065159	875.7	0.6	402.1	441294	48865648	48804400	192558	585345	[illegible]
	SRB LEFT SEPARATION	186453	1802.6	-250.9	401.0	188161	11824861	11828475	-25231	8902	-459
	SRB LEFT INFLIGHT LOSSES	1116562	1696.8	-250.9	400.1	736224	35414985	35415330	1502	232	-2
	SRB LEFT AT IGN. RSRML-001	1303015	1711.9	-250.6	400.2	924419	47626228	47630161	-25007	12542	456
	SRB RIGHT SEPARATION	186453	1802.6	250.9	401.0	188161	11824861	11828475	25231	8902	-459
	SRB RIGHT INFLIGHT LOSSES	1116562	1696.8	250.5	400.1	736224	35414985	35415330	-1502	232	2
	SRB RIGHT AT IGN. RSRML-001	1303015	1711.9	250.6	400.2	924419	47626228	47630161	25007	12542	-456
I	TOTAL MASS PROPERTIES AT SRB IGN	4538082	1414.6	0.2	419.5	43964421	323149077	353310325	20859	8839991	31649

ORBITER AND CARGO IN ORBITER COORDINATE SYSTEM. ET, SRB, AND SHUTTLE TOTAL IN SHUTTLE COORDINATE SYSTEM.

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National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
Houston, Texas
77058

3A NASA

Reply to Attn of: TM4-87-031

NOV 18 1987

TO: NASA Headquarters
Attn: M/Director, National Space Transportation System

FROM: GA/Deputy Director, National STS Program

SUBJECT: Update to Space Transportation System (STS) Ascent Performance and Landing Weight Capability

The previously reported Shuttle ascent performance and landing weight capability (refer to letter TM4-87-010) has been updated to reflect changes to the allowable payload capability. Enclosed you will find updated versions of the Shuttle Ascent Performance Capability, the Shuttle Landing Weight Capability, and the associated Ground Rules and Assumptions. All previous versions of this material should be discarded. The only major updates involve Shuttle landing weight capability as summarized below.

Several changes to ascent performance capability have occurred in the last 4 months. However, the performance losses have been offset by performance gains and the STS ascent performance capability is essentially unchanged. The performance losses result from a 300-pound increase to the Orbiter system weight and a 300-pound performance loss because of an increase in the inert weight of the redesigned solid rocket motor. This 600-pound loss in ascent performance is offset by a 600-pound performance gain resulting from an adjustment to the main propusion system propellant budget.

As a result of the 300-pound Orbiter system inert weight increase, the cargo landing weight capabilities have been reduced by 300 pounds. A significant increase in nominal end of mission (NEOM) landing weight capability results from increasing the NEOM landing weight limit to 230,000 pounds.

The incremental weight adjustment for an additional crew person (such as a payload specialist) has been increased to 500 pounds. This increase from 450 pounds accounts for individual crew escape equipment.

We hope this update is helpful in keeping abreast of the National Space Transportation System (NSTS) capability. Updates to the NSTS ascent performance and landing weight capability will be provided quarterly.

Original Signed By:
RICHARD H. KOHRS

Richard H. Kohrs

3 Enclosures

SHUTTLE ASCENT PERFORMANCE CAPABILITY

11-20-87

		ETR			WTR		
		MAX. PERF. 28.5 DEG, 110 NM	MAX. PERF. 57.0 DEG, 110 NM	SPACE STATION 28.5 DEG 220 NM	MAX. PERF. 68.0 DEG, 110 NM	MAX. PERF. 98.0 DEG, 110 NM	SPACE STATION POLAR MISSION 140 NM
o PRE STS 51-L CAPABILITY @ 104% SSME		61,400 LIMITED TO 54,300 BY DOWN WEIGHT	47,400	45,930	48,600	28,800	21,600
o NEAR-TERM CAPABILITY @ 104% SSME		55,000 LIMITED TO 50,200 BY DOWNWEIGHTS PROIR TO 6.0 LOADS ANALYSIS	41,000	39,530			
o ACHIEVABLE CAPABILITY WITH CURRENTLY PLANNED HARDWARE, MARGIN TESTING & ANALYSIS	104% SSME	55,500	41,500	40,030			
	109% SSME	60,500 LIMITED TO 57,700 BY DOWNWEIGHTS AFTER 6.0 LOADS ANALYSIS	46,500	45,030			
o POTENTIAL CAPABILITY WITH THE ASRM (12,000 POUNDS)	104% SSME	67,500 *	53,500	52,030	49,600	29,600	22,500
	109% SSME	72,500 *	58,500	57,030	54,600	34,600	27,500

NOTES: - CAPABILITY EQUATES TO PAYLOAD PLUS ATTACH HARDWARE.

- SUBTRACT APPROXIMATELY 100 LB/NM FOR INCREASED ALTITUDES.

- CAPABILITY SHOWN IS FOR ORBITERS OV-103, 104, & 105; SUBTRACT APPROXIMATELY 8,400 POUNDS TO USE ORBITER OV-102

* THIS CAPABILITY CAN ONLY BE USED IF THE ORBITER ABORT LANDING WEIGHT LIMITS ARE CERTIFIED TO 258,300 POUNDS FOR THE 67,500-POUND CAPABILITY, AND 263,300 POUNDS FOR THE 72,500-POUND CAPABILITY. THIS IS A SIGNIFICANT INCREASE OVER THE CURRENT GOAL OF 248,000 POUNDS AND MAY REQUIRE SIGNIFICANT MODIFICATIONS TO THE STRUCTURAL DESIGN OF THE ORBITER. THE FEASIBILITY OF THESE MODIFICATIONS IS UNKNOWN.

SHUTTLE LANDING-WEIGHT CAPABILITY

11-20-87

ORBITER CONFIGURATION	MAXIMUM PERFORMANCE	SPACE STATION (ETR)	SPACELAB
O CREW SIZE / DURATION	5 MAN / 4 DAY	5 MAN / 7 DAY	5 MAN / 7 DAY
O CRYO (HARDWARE / FLUID LEVEL)	3 TANKS / 3 OFFLOADED	4 TANKS / 3 FULL	4 TANKS / 4 FULL
O FORWARD RCS	OFFLOADED	FULL	FULL
O RMS	OFF	ON	OFF

	MAXIMUM PERFORMANCE CONFIGURATION		SPACE STATION (ETR)	SPACELAB
	RTLS	AOA	NEOM	NEOM
CURRENT LANDING LIMITS	240,000	240,000	230,000	230,000
ORBITER SYSTEM	187,816	187,232	185,479	184,501
WEIGHT GROWTH PORTION OF MANAGERS RESERVE	2,000	2,000	2,000	2,000
NEAR TERM LANDING WEIGHT CAPABILITY	50,184	50,768	42,521	43,499
6.0 LANDING LIMITS	254,000	248,000	230,000	230,000
ORBITER SYSTEM	187,816	187,232	185,479	184,501
WEIGHT GROWTH PORTION OF MANAGERS RESERVE	2,000	2,000	2,000	2,000
CAT II MODS AND NOMINAL WEIGHT GROWTH FOR THE MID 90'S	1,000	1,000	1,000	1,000
ACHIEVABLE LANDING WEIGHT CAPABILITY	63,184	57,768	41,521	42,499

NOTES :
- RTLS AND TAL ARE NOT LIMITING CASES FOR SPACE STATION AND SPACELAB CONFIGURATIONS.
- CAPABILITY SHOWN IS FOR ORBITERS OV-103, 104, & 105; SUBTRACT ~ 8,400 LBS WHEN USING ORBITER OV-102.
- EACH ADDITIONAL CREW PERSON BEYOND THE FIVE PERSON STANDARD IS CHARGEABLE TO THE CARGO WEIGHT ALLOCATION AND WILL REDUCE THE PAYLOAD CAPABILITY BY APPROXIMATELY 500 POUNDS.

SHUTTLE PERFORMANCE
GROUND RULES AND ASSUMPTIONS

11-20-87

ORBITER CONFIGURATION:	MAXIMUM PERFORMANCE	SPACE STATION - ETR	SPACE STATION - WTR
O CREW SIZE / DURATION	5 MAN / 4 DAY	5 MAN / 7 DAY	5 MAN / 7 DAY
O CRYO (HARDWARE / FLUID LEVEL)	3 TANKS / 3 OFFLOADED	4 TANKS / 3 FULL	3 TANKS / 3 FULL
O FORWARD RCS	OFFLOADED	FULL	FULL
O RMS	OFF	ON	ON
O RENDEZVOUS	NO	YES	YES

NEAR-TERM CAPABILITY - LATE 1980'S TO EARLY 1990'S

O ASCENT SHAPING : Q - 790 FLUTTER BUFFET ; Q alpha - -3250;

O THE QUOTED CAPABILITY INCLUDES DISCOUNTS FOR MANAGER'S RESERVE AND FOR THE CREW ESCAPE SYSTEM, SRB REDESIGN, AND ORBITER MODIFICATIONS RESULTING FROM STS 51-L.

ACHIEVABLE CAPABILITY - EARLY TO MID 1990'S

O ASCENT SHAPING : Q - 819 TPS ; Q alpha - -3000 ; PERFORMANCE INCREASES BY :

+1500 LBS @ ETR   +2,300 LBS @ WTR

O POTENTIAL WEIGHT GROWTH FOR CAT II MODS & NOMINAL WEIGHT GROWTH IN THE 1990'S; PERFORMANCE DECREASES BY :

-1000 LBS @ BOTH SITES

POTENTIAL CAPABILITY - MID TO LATE 1990'S

O SAME AS ACHIEVABLE CAPABILITY GROUND RULES

O ADVANCED SRM : 12,000 LBS AS A PERFORMANCE INCREASE DESIGN GOAL. FOR THIS ASSESSMENT WE ARE ASSUMING THAT THE ASRM REPLACES THE FWC SRM.

NOTE : - EACH ADDITIONAL CREW PERSON BEYOND THE FIVE PERSON STANDARD IS CHARGEABLE TO THE CARGO WEIGHT ALLOCATION AND WILL REDUCE THE PAYLOAD CAPABILITY BY APPROXIMATELY 500 POUNDS.

cc:
NASA Hqs., M/R. H. Truly
KSC, CM/J. T. Conway
TM/T. E. Utsman
R. B. Sieck
G. T. Sasseen
TP/C. D. Gay
TV/J. E. Smith
NSTS-KSC, MK/R. L. Crippen
MSFC, EE01/J. A. Lovingood
SA21/J. A. Lombardo
SA31/G. P. Bridwell
SA41/G. W. Smith
EE01/J. A. Lovingood
SA71/J. W. Kennedy
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EA/H. O. Pohl
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B. D. O'Connor
GA2/J. B. Costello
GA3/M. E. Merrell
GM/D. C. Schultz
MJ/R. A. Thorson
TA/L. S. Nicholson
TM/A. A. Bishop
TM2/G. C. Nield
TM4/R. E. Matthews
VK/J. G. Presnell
C. M. Vaughn
WA/R. W. Moorehead
L. G. Williams
T. T. Henricks

TM4/CMCarothers:el:11/13/87:31364

LRB REFERENCE MISSION OPTIONS
DECEMBER 16, 1987

Johnson Space Center - Houston, Texas

LRB REFERENCE MISSIONS

Advanced Programs Office

D. Blumentritt/LEMSCO | 12/16/87

SHUTTLE ASCENT PERFORMANCE CAPABILITY

11-20-87

		ETR			WTR		
		MAX. PERF. 28.5 DEG, 110 NM	MAX. PERF. 57.0 DEG, 110 NM	SPACE STATION 28.5 DEG 220 NM	MAX. PERF. 68.0 DEG, 110 NM	MAX. PERF. 98.0 DEG, 110 NM	SPACE STATION POLAR MISSION 140 NM
o PRE STS 51-L CAPABILITY @ 104% SSME		61,400 LIMITED TO 54,300 BY DOWN WEIGHT	47,400	45,930	48,600	28,800	21,600
o NEAR-TERM CAPABILITY @ 104% SSME		55,000 LIMITED TO 50,200 BY DOWNWEIGHTS PROIR TO 6.0 LOADS ANALYSIS	41,000	39,530			
o ACHIEVABLE CAPABILITY WITH CURRENTLY PLANNED HARDWARE, MARGIN TESTING & ANALYSIS	104% SSME	55,500	41,500	40,030			
	109% SSME	60,500 LIMITED TO 57,700 BY DOWNWEIGHTS AFTER 6.0 LOADS ANALYSIS	46,500	45,030			
o POTENTIAL CAPABILITY WITH THE ASRM (12,000 POUNDS)	104% SSME	67,500 *	53,500	52,030	49,600	29,600	22,500
	109% SSME	72,500 *	58,500	57,030	54,600	34,600	27,500

NOTES:
- CAPABILITY EQUATES TO PAYLOAD PLUS ATTACH HARDWARE.
- SUBTRACT APPROXIMATELY 100 LB/NM FOR INCREASED ALTITUDES.
- CAPABILITY SHOWN IS FOR ORBITERS OV-103, 104, & 105; SUBTRACT APPROXIMATELY 8,400 POUNDS TO USE ORBITER OV-102

* THIS CAPABILITY CAN ONLY BE USED IF THE ORBITER ABORT LANDING WEIGHT LIMITS ARE CERTIFIED TO 258,300 POUNDS FOR THE 67,500 POUND CAPABILITY, AND 263,300 POUNDS FOR THE 72,500 POUND CAPABILITY. THIS IS A SIGNIFICANT INCREASE OVER THE CURRENT GOAL OF 248,000 POUNDS AND MAY REQUIRE SIGNIFICANT MODIFICATIONS TO THE STRUCTURAL DESIGN OF THE ORBITER. THE FEASIBILITY OF THESE MODIFICATIONS IS UNKNOWN

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LRB REFERENCE MISSIONS

SHUTTLE LANDING-WEIGHT CAPABILITY

D. Blumentritt/LEMSCO

12/16/87

ORBITER CONFIGURATION	MAXIMUM PERFORMANCE	SPACE STATION (ETR)	SPACELAB
O CREW SIZE / DURATION	5 MAN / 4 DAY	5 MAN / 7 DAY	5 MAN / 7 DAY
O CRYO (HARDWARE / FLUID LEVEL)	3 TANKS / 3 OFFLOADED	4 TANKS / 3 FULL	4 TANKS / 4 FULL
O FORWARD RCS	OFFLOADED	FULL	FULL
O RMS	OFF	ON	OFF

	MAXIMUM PERFORMANCE CONFIGURATION		SPACE STATION (ETR)	SPACELAB
	RTLS	AOA	NEOM	NEOM
CURRENT LANDING LIMITS	240,000	240,000	230,000	230,000
ORBITER SYSTEM	187,816	187,232	185,479	184,501
WEIGHT GROWTH PORTION OF MANAGERS RESERVE	2,000	2,000	2,000	2,000
NEAR TERM LANDING WEIGHT CAPABILITY	50,184	50,768	42,521	43,499
6.0 LANDING LIMITS	254,000	248,000	230,000	230,000
ORBITER SYSTEM	187,816	187,232	185,479	184,501
WEIGHT GROWTH PORTION OF MANAGERS RESERVE	2,000	2,000	2,000	2,000
CAT II MODS AND NOMINAL WEIGHT GROWTH FOR THE MID 90'S	1,000	1,000	1,000	1,000
ACHIEVABLE LANDING WEIGHT CAPABILITY	63,184	57,768	41,521	42,499

NOTES :
- RTLS AND TAL ARE NOT LIMITING CASES FOR SPACE STATION AND SPACELAB CONFIGURATIONS.
- CAPABILITY SHOWN IS FOR ORBITERS OV-103, 104, & 105; SUBTRACT - 8,400 LBS WHEN USING ORBITER OV-102.
- EACH ADDITIONAL CREW PERSON BEYOND THE FIVE PERSON STANDARD IS CHARGEABLE TO THE CARGO WEIGHT ALLOCATION AND WILL REDUCE THE PAYLOAD CAPABILITY BY APPROXIMATELY 500 POUNDS.

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SHUTTLE PERFORMANCE
GROUND RULES AND ASSUMPTIONS

Advanced Programs Office

D. Blumentritt/LEMSCO

12/16/87

ORBITER CONFIGURATION:	MAXIMUM PERFORMANCE	SPACE STATION - ETR	SPACE STATION - WTR
O CREW SIZE / DURATION	5 MAN / 4 DAY	5 MAN / 7 DAY	5 MAN / 7 DAY
O CRYO (HARDWARE / FLUID LEVEL)	3 TANKS / 3 OFFLOADED	4 TANKS / 3 FULL	3 TANKS / 3 FULL
O FORWARD RCS	OFFLOADED	FULL	FULL
O RMS	OFF	ON	ON
O RENDEZVOUS	NO	YES	YES

NEAR-TERM CAPABILITY - LATE 1980'S TO EARLY 1990'S

O ASCENT SHAPING : Q - 790 FLUTTER BUFFET ; Q alpha - -1250;

O THE QUOTED CAPABILITY INCLUDES DISCOUNTS FOR MANAGER'S RESERVE AND FOR THE CREW ESCAPE SYSTEM, SRB REDESIGN, AND ORBITER MODIFICATIONS RESULTING FROM STS 51-L.

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+1500 LBS @ ETR   +2,300 LBS @ WTR

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-1000 LBS @ BOTH SITES

POTENTIAL CAPABILITY - MID TO LATE 1990'S

O SAME AS ACHIEVABLE CAPABILITY GROUND RULES

O ADVANCED SRM . 12,000 LBS AS A PERFORMANCE INCREASE DESIGN GOAL.
FOR THIS ASSESSMENT WE ARE ASSUMING THAT THE ASRM REPLACES THE FWC SRM.

NOTE : EACH ADDITIONAL CREW PERSON BEYOND THE FIVE PERSON STANDARD IS CHARGEABLE TO THE CARGO WEIGHT ALLOCATION AND WILL REDUCE THE PAYLOAD CAPABILITY BY APPROXIMATELY 500 POUNDS.

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		MAX PERF. 28.5 DEG. 160 NM	SPACE STATION 28.5 DEG 220 NM	INCREASED PERFORMANCE GOAL	DELTA FROM ASRM	COMMENTS
O ASRM DESIGN GOALS	104% SSME	62500 *	52030	12000	--	RE., ALDRICH MEMO
	109% SSME	67500 *	57030	12000	--	RE., ALDRICH MEMO
O LRB BRM-1 (59KLB TO 150 NM)	104% SSME	58000	47530	7500	-4500	TDDP LRBRM-1
O LRB BRM-2 (70KLB TO 150NM)	100% SSME	69000 *	58530 **	22500	10500	TDDP LRBRM-2
	104% SSME	73000 *	62530 **	22500	10500	FOR INFO ONLY
O SPACE STATION MAX CAPABILITY BASED ON SHKLB DOWN-WEIGHT LIMIT	100% SSME	68470 *	58000	21970	9970	RE.,PRCB CR 40313B
	104% SSME	68470 *	58000	17970	5970	RE.,PRCB CR 40313B

* LIMITED TO 58000 LB BY MAXIMUM AOA DOWNWEIGHT CONSTRAINT

** LIMITED TO 58000 LB BY CONTINGENCY PAYLOAD RETURN DOWNWEIGHT CONSTRAINT RE., PRCB CR # 40313B

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RECOMMENDATIONS

- O RETAIN 69KLB TO 160 NM CARGO WEIGHT FOR LRB BRM-2 TO REPRESENT MAXIMUM SPACE STATION PERFORMANCE CAPABILITY (EQUIVALENT TO 70KLB TO 150 NM)
- O REVISE LRB BRM-2 CARGO WEIGHT TO REFLECT ASRM DESIGN PERFORMANCE GOAL (62500 LB TO 160 NM)

LRB REFERENCE MISSION OPTIONS
DECEMBER 16, 1987

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12/16/87

SHUTTLE ASCENT PERFORMANCE CAPABILITY

11-20-87

		ETR			WTR		
		MAX. PERF. 28.5 DEG, 110 NM	MAX. PERF. 57.0 DEG, 110 NM	SPACE STATION 28.5 DEG 220 NM	MAX. PERF. 68.0 DEG, 110 NM	MAX. PERF. 98.0 DEG, 110 NM	SPACE STATION POLAR MISSION 140 NM
o PRE STS 51-L CAPABILITY @ 104% SSME		61,400 LIMITED TO 54,300 BY DOWN WEIGHT	47,400	45,930	48,600	28,800	21,600
o NEAR-TERM CAPABILITY @ 104% SSME		55,000 LIMITED TO 50,200 BY DOWNWEIGHTS PROIR TO 6.0 LOADS ANALYSIS	41,000	39,530			
o ACHIEVABLE CAPABILITY WITH CURRENTLY PLANNED HARDWARE, MARGIN TESTING & ANALYSIS	104% SSME	55,500	41,500	40,030			
	109% SSME	60,500 LIMITED TO 57,700 BY DOWNWEIGHTS AFTER 6.0 LOADS ANALYSIS	46,500	45,030			
o POTENTIAL CAPABILITY WITH THE ASRM (12,000 POUNDS)	104% SSME	67,500 *	53,500	52,030	49,600	29,600	22,500
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LRB REFERENCE MISSIONS

SHUTTLE LANDING-WEIGHT CAPABILITY

Advanced Programs Office

D. Blumentritt/LEMSCO

12/16/87

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SHUTTLE PERFORMANCE
GROUND RULES AND ASSUMPTIONS

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	109% SSME	67500 *	57030	12000	--	RE., ALDRICH MEMO
0 LRB BRM-1 (59KLB TO 150 NM)	104% SSME	58000	47530	7500	-4500	TDDP LRBRM-1
0 LRB BRM-2 (70KLB TO 150NM)	100% SSME	69000 *	58530 **	22500	10500	TDDP LRBRM-2
	104% SSME	73000 *	62530 **	22500	10500	FOR INFO ONLY
0 SPACE STATION MAX CAPABILITY BASED ON 58KLB DOWN-WEIGHT LIMIT	100% SSME	68470 *	58000	21970	9970	RE.,PRCB CR 40313B
	104% SSME	68470 *	58000	17970	5970	RE.,PRCB CR 40313B

* - LIMITED TO 58000 LB BY MAXIMUM AOA DOWNWEIGHT CONSTRAINT

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	D. Blumentritt/LEMSCO	12/16/87

RECOMMENDATIONS

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- O REVISE LRB BRM-2 CARGO WEIGHT TO REFLECT ASRM DESIGN PERFORMANCE GOAL (62500 LB TO 160 NM)

JSC/LEMSCO LOADS ANALYSIS CAPABILITIES

JSC/LEMSCO TOOLS

- SIX DEGREE-OF-FREEDOM (DOF) TRAJECTORIES ARE GENERATED USING SPACE VEHICLE DYNAMICS SIMULATION (SVDS) PROGRAM WHICH IS USED FOR ASCENT FLIGHT DESIGN AND ANALYSIS AT THE JOHNSON SPACE CENTER ON UNISYS 1100 SERIES COMPUTER SYSTEM

  -- LRB/STS AERO DATABASE CAN BE IMPLEMENTED INTO SVDS, BUT WILL REQUIRE MODIFICATIONS TO THE AERO DATA PROCESSOR TO CREATE DATABASE

  -- GN&C FLIGHT SOFTWARE IS MODELLED IN SVDS

  -- MODIFICATIONS TO THE GN&C FLIGHT SOFTWARE IN SVDS CAN BE MADE FOR LRB/STS INTEGRATED STACK

  -- FORCE, MOMENT, C.G. AND ASCENT TRAJECTORY PARAMETERS TIME HISTORIES ARE OUTPUT FOR USE IN THE LOADS ANALYSIS PROGRAMS

- ORTHOGONAL AND STRUT LOADS CAN BE COMPUTED USING LOAD-CONVERT (LDCON) PROGRAM ON THE JSC/ADVANCED PROGRAMS OFFICE (APO) HARRIS-800 COMPUTER SYSTEM

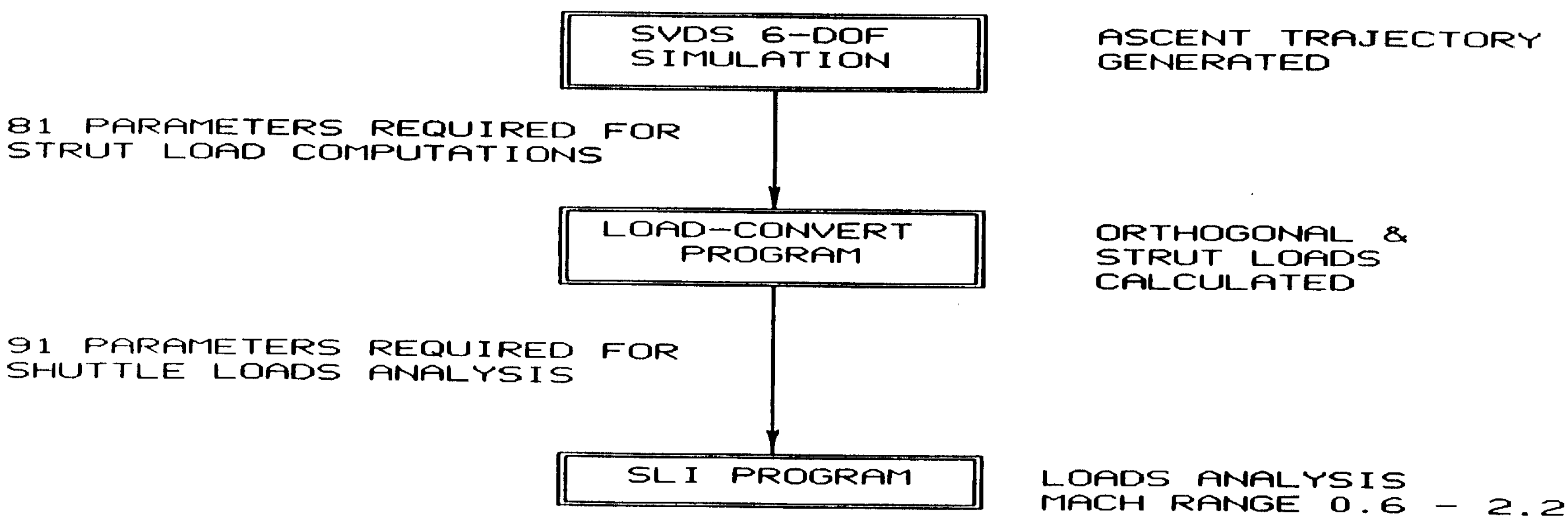
  -- CURRENT ORTHOGONAL AND STRUT LOADS EQUATIONS CAN BE EMPLOYED IF LRBs ARE SIZED THE SAME AS CURRENT SRBs

  -- NEW ORTHOGONAL AND STRUT LOADS EQUATIONS WOULD HAVE TO BE DEVELOPED IF SIZING DIFFERENCES TO THE CURRENT STACK ARE INTRODUCED

- SHUTTLE LOAD INDICATOR (SLI) ANALYSIS CAPABILITIES EXIST USING JSC/APO SLI PROGRAM (ALSO ON THE HARRIS-800 SYSTEM)

  -- SLI PROGRAM ALGORITHMS CAN BE MODIFIED TO REFLECT NEW ALGORITHMS AND/OR NEW ALGORITHM COEFFICIENTS GENERATED VIA RESULTS FROM NASTRAN ANALYSIS AND EMPIRICAL TESTING

CURRENT LOADS ANALYSIS DATA PROCESSING



NEW DATA REQUIRED FROM AN OUTSIDE SOURCE

- SVDS – SIX-DOF ASCENT TRAJECTORY SIMULATION
  - -- LRB/STS AERO DELTA COEFFICIENTS (FROM MSFC)
  - -- ESTIMATE OF C.G. FOR DRY LRBs (FROM MARTIN AND GENERAL DYNAMICS)
  - -- ESTIMATE OF C.G. VS WEIGHT HISTORY OF EACH LRB TANK (FROM MARTIN AND GENERAL DYNAMICS)
- LDCON – ORTHOGONAL & STRUT LOADS CALCULATION PROGRAM
  - -- STRUT LENGTHS AND GEOMETRY (FROM MARTIN AND GENERAL DYNAMICS) IF DIFFERENT FROM CURRENT STS
  - -- AERODYNAMIC DATA FROM EMPIRICAL WIND TUNNEL TESTING (FROM MSFC)
- SLI – SHUTTLE LOAD INDICATOR ANALYSIS PROGRAM
  - -- NEW LOAD INDICATOR COEFFICIENTS AND/OR ALGORITHMS FROM NASTRAN ANALYSIS AND EMPIRICAL WIND TUNNEL TESTING FOR ORBITER, ET AND LRBs (FROM LMSC/HUNTSVILLE)

LOADS ANALYSIS RECOMMENDATIONS

- USE SIMPLE LOAD INDICATORS FOR TESTING ALL CANDIDATE LRB/STS DESIGN CONFIGURATIONS
  - -- ELEMENT WING ROOT BENDING, SHEER AND TORSION EQUATIONS
  - -- ELEMENT TAIL ROOT BENDING, SHEER AND TORSION EQUATIONS
- PERFORM COMPLETE 6-DOF SHUTTLE LOADS INDICATOR ANALYSIS ON DESIGN FINALISTS
  - -- JUST PRIOR TO DOWN-SELECT TO ASSIST IN DECISION PROCESS ON CLOSE CALLS
  - -- AFTER DOWN-SELECT ON ALL DESIGN CONFIGURATIONS

LRB/STS SYSTEMS INTEGRATION TASK STATUS

PRESENTATION OVERVIEW

- STUDIES CONDUCTED
  - --SUMMARY (Carter)
  - --PERFORMANCE TRENDS (Kelly)
  - --LOADS ANALYSIS CAPABILITIES (Fardelos)
- LRB ABORT CAPABILITIES SUMMARY (Blumentritt)
- INTEGRATION ISSUES (Akkerman)
- FY 88 MAJOR TASKS/SUBTASKS (McCurry)
- FY 88 SCHEDULE (McCurry)

SUMMARY

- STS-26 CYCLE 1B
  --SIMULATION AND OPTIMIZATION OF ROCKET TRAJECTORIES (SORT)
  --CONCEPTUAL ABORT REGION DETERMINATOR (CARD)
  --SPACE VEHICLE DYNAMICS SIMULATION (SVDS)

- "LAB RAT" BOOSTER (W. Kelly/LEMSCO)
  --PUMP-FED, LOX/METHANE
  --SIZED ON IDEAL VELOCITY REQUIREMENTS (BURN TIME = 140 sec)
  --T/W= 1.25 @ L.O.; 5 ENGINES (400K lbf CLASS)
  --TOTAL THRUST PER BOOSTER = 1.8 Million lbf

- "LAB RAT" BOOSTER
  --SORT/CARD

- MARTIN MARIETTA CONFIGURATION # 1
  --SORT/CARD

- MARTIN MARIETTA CONFIGURATION # 1, USING THE LRB BASE REFERENCE MISSION #2 (69K lbf TO 160 nm)
  --SORT

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LRB/STS SYSTEMS INTEGRATION	Advanced Programs Office	
	J.W. Akkerman/ED13	12/16/87

INTEGRATION ISSUES

- SYSTEM INTERFACES/AUTONOMY
- AERODYNAMIC LOADS
- LOAD PATHS/LOAD LIMITS
- ABORTS
- OPERATIONAL ISSUES
- EVIRONMENTAL IMPACTS
- GROWTH POTENTIAL

SYSTEM INTERFACES/AUTONOMY

- ELECTRICAL POWER
  - --NUMBER OF CIRCUITS
  - --POWER AVAILABLE
  - --ENERGY AVAILABLE

- AVIONICS
  - --GN&C
  - --EVENT SEQUENCING
  - --TELEMETRY
  - --HEALTH MONITORING
  - --PROPELLANT UTILIZATION

- TVC
  - --SUPPORTING SUBSYSTEM REQUIREMENTS
    - APU/HPU
    - FLEX LINES
    - GIMBAL HARDWARE
    - LIQUID INJECTION SYSTEMS
  - --CONTROLLER LOGIC/MIXING
  - --FAILURE IMPLICATIONS (ACTIVE/PASSIVE)

AERODYNAMIC LOADS

- STS PERFORMANCE TYPICALLY COUPLED TO LOADS
- LRB SIZE COUPLED TO STS PERFORMANCE AND STS LOADS
- PERFORMANCE INCREASE REQUIRED
- LOAD REDUCTION DESIRED
- REQUIREMENT APPEARS TO CONFLICT WITH DESIRE
- FACTORS
  --WING LOADING IS DOMINANT CONSTRAINT
  --ANGLE-OF-ATTACK (ALPHA) CAN BE ADJUSTED
  --DYNAMIC PRESSURE (Q BAR) CAN BE ADJUSTED
  --BOOSTER GEOMETRY CAN BE ADJUSTED
- STATUS: PERFORMANCE INCREASE APPEARS TO BE ACHIEVABLE WITH LOAD REDUCTION

LOAD PATHS/LOAD LIMITS

- BOOSTER LOADS
  - --STACK WEIGHT (PRESSURE-FED VS. PUMP-FED)
  - --ATTACH-STRUT LOADS
    - THERMAL
    - PRESSURE
  - --TWANG ABATEMENT (START-UP/SHUT-DOWN/LIFT-OFF)
  - --ACOUSTIC/OVERPRESSURE/FLOW
  - --RETRIEVAL/IMPACT LOADS
- ORBITER LOADS
  - --TWANG REACTION LOADS
  - --AERODYNAMIC-INDUCED LOADS
- ET LOADS
  - --AFT LOX BULKHEAD
  - --REACTION TO LRB THRUST LOADS (THRUST BEAM/INTERTANK PANELS)

ABORTS

- NO NEW ABORT MODES ARE PRESENTED

- LRB DESIGNED TO PROTECT FOR INTACT ABORTS, FOR ONE LRB ENGINE OUT AT LIFT-OFF**

- HOWEVER, ADDITIONAL OPPORTUNITIES TO USE CURRENT MODES

--PAD ABORT
- WITH SSME OUT
- WITH LRB ENGINE OUT**

--INTACT ABORT
- WITH SSME OUT
- WITH LRB ENGINE OUT**
  --RTLS, TAL, ATO, AOA

--ENHANCED NON-INTACT ABORTS
- EXPAND SPLIT-S COVERAGE
- IMPROVE FAST-SEP. CONDITIONS

** IF MULTIPLE ENGINES PER BOOSTER

ABORTS (CONCLUDED)

- EXTRA LRB/STS PERFORMANCE PROVIDES:
  - --LATER NEGATIVE RETURN (LAST RTLS)
  - --EARLIER PRESS-TO-TAL
  - --EARLIER PRESS-TO-ATO
  - --EARLIER PRESS-TO-MECO
  - --OVERLAP OF ATO & RTLS <u>MAY</u> ELIMINATE TAL COVERAGE REQUIREMENT (FROM PERFORMANCE STANDPOINT)

OPERATIONAL ISSUES

- LAUNCH PROBABILITY (PRESENTLY ABOUT 85%)
  - --WINDS ALOFT DRIVE Q BAR, Q BAR-ALPHA, SIDESLIP
  - --DOWN-RANGE WEATHER

- EFFECTS OF LAUNCH SLIPS
  - --STS IMPACTS (LITTLE "SLACK TIME" FOR MAKE-UP)
  - --INTERFACING PROGRAM IMPACTS

- MISSION DESIGN/FLIGHT OPERATIONS
  - --GENERIC MISSIONS (INCREASED PERFORMANCE ENVELOPE)
  - --TIMING/DAY-OF-LAUNCH FLEXIBILITY
  - --REDUCED RECONFIGURATION LEAD TIME

- TURNAROUND SEQUENCING/TIMELINE
  - --VAB SCHEDULE
  - --SAFETY CONSTRAINTS

OPERATIONAL ISSUES (CONCLUDED)

- RETRIEVAL/REFURB./ECONOMICS
- RANGE SAFETY
  --SHUT-DOWN POTENTIAL
  --REDUCED RISK
- REPEATABILITY OF BOOSTER PERFORMANCE
  --ADAPTIVE GUIDANCE

ENVIRONMENTAL IMPACTS

- BECOMES MORE AN ISSUE DAILY
  - --MORE PEOPLE/CLOSER
  - --LAUNCH FACILITY/TEST FACILITY

- SRBs GENERATE PROBLEMS
  - --NORMALLY "ON COMMAND"
  - --ACCEPT RESULTS RATHER THAT CONSTRAIN ON TIME & WINDS

- HYPERGOLICS DO NOT GENERATE AS MUCH OF A PROBLEM, <u>BUT</u>
  - --SPILLS CAN BE UNTIMELY
  - --EFFECTS MORE SPECTACULAR AND FAR-REACHING

- LOX/HYDROCARBON MOST COMPATIBLE FLUIDS
  - --SPILLS CAN BE A PROBLEM
  - --EFFECTS MORE LOCALIZED
  - --NORMAL OPERATION ENTIRELY ACCEPTABLE

GROWTH POTENTIAL

- PERFORMANCE MARGIN NORMALLY USED FOR OTHER BENEFITS CAN BE USED OCCASIONALLY FOR HEAVY LOADS
  --FLY HIGHER Q_BAR
  --ACCEPT REDUCED ABORT MARGINS
  --ACCEPT HIGHER SSME STRESS/WEAR
  --ACCEPT LOWER LAUNCH PROBABILITY
  --ACCEPT LAUNCH DATE/TIME CONSTRAINTS
  (GO BACK TO TODAY'S MODE OCCASIONALLY)

- PRODUCT IMPROVEMENT FEATURES
  --METALIZED PROPELLANTS
  --TANK QUALITY/OPERATING PRESSURE INCREASES
  --BURNER EFFICIENCY IMPROVEMENTS
  --PRESSURIZATION SYSTEM REFINEMENTS

- CARGO CARRIER FOR HAZARDOUS MATERIALS/BULK ITEMS

- POTENTIAL USE WITH OTHER CORE VEHICLES (MULTIPLE UNITS)

FY 88 MAJOR TASKS/SUBTASKS

(1) SYSTEM INTERFACE TRANSACTION IDENTIFICATION & ANALYSIS

(2) ASCENT/ABORT PERFORMANCE ANALYSIS

(3) SYSTEMS INTEGRATION ANALYSIS OF CANDIDATE LRB DESIGNS

(4) LRB PROGRAMMATICS ANALYSIS

(5) FLIGHT PLANNING/MISSION OPS. ANALYSIS

(6) AERO LOADS ANALYSIS
--ANALYSIS TOOL MODIFICATION
--LOADS ANALYSIS/VERIFICATION
--ORBITER STUCTURES ASSESSMENT

FY 88 MAJOR TASKS/SUBTASKS (CONTINUED)

(7) STS AERO DATABASE MODIFICATION
- --ANALYSIS TOOL MODIFICATION
- --DATABASE MODIFICATION/VERIFICATION

(8) VEHICLE SIMULATION TOOL MODIFICATION/VERIFICATION
- --3-DOF TOOLS
- --6-DOF TOOLS

(9) HOLD-DOWN/LAUNCH DYNAMICS ANALYSIS

(10) HEATING ANALYSIS
- --AERO HEATING
- --PLUME HEATING

(11) SEPARATION DYNAMICS ANALYSIS
- --ANALYSIS TOOL DEVELOPMENT
- --DYNAMICS ANALYSIS

FY 88 MAJOR TASKS/SUBTASKS (CONTINUED)

(12) ROCKWELL (DOWNEY) INTEGRATION ASSESSMENT
- --CERTIFICATION PLAN DEVELOPMENT (MATED-VEHICLE)
- --VALIDATION OF JSC INTEGRATION ASSESSMENT (MATED-VEHICLE)
- --AERO LOADS ANALYSIS SUPPORT

(13) STSOC INTEGRATION ASSESSMENT
- --FACILITIES/RESOURCES IMPACT ASSESSMENTS (COMPLETION-FORM & LOE)

(14) MARTIN MARIETTA MICHOUD INTEGRATION ASSESSMENT
- --ET STRUCTURES/SYSTEMS IMPACT ASSESSMENTS

(15) PHASE A INTEGRATION REPORT
- --PRELIMINARY REPORT
- --FINAL REPORT

(16) LRB PHASE B RFP DEVELOPMENT

(17) LAUNCH VEHICLE INPUT/OUTPUT SYSTEMS ANALYSIS TEMPLATE DEVELOPMENT

FY 88 MAJOR TASKS/SUBTASKS (CONCLUDED)

(18) LRB APPLICATIONS ANALYSIS FOR ADVANCED LAUNCH VEHICLES
- --CORE VEHICLE SIZING CONFIGURATION & PERFORMANCE ANALYSIS
- --LRB SYSTEM REQUIREMENTS ANALYSIS
- --LRB/CORE VEHICLE INTERFACE REQUIREMENTS ANALYSIS
- --PROGRAMMATICS ANALYSIS

(19) LRB UTILIZATION TRADE STUDIES

(20) SRB UTILIZATION/DESIGN IMPROVEMENTS

FY 88 SCHEDULE

Johnson Space Center - Houston, Texas

LRB/STS SYSTEMS INTEGRATION

Advanced Programs Office

J.B. McCurry/LEMSCO | 12/16/87

J.B. McCurry
APPROVAL M.A. Cole
ACCOMP.

JSC INTEGRATION TASK, FY 1988

Page 1 of 3

ORIG. APPVL. 11/24/87
LAST CHANGE 12/02/87
STATUS AS OF 12/02/87

	MILESTONES	87 O	87 N	87 D	88 J	88 F	88 M	88 A	88 M	88 J	88 J	88 A	88 S
01	System Interface Transaction												
02	Identification and Anal.												
03													
04	Ascent/Abort Performance Anal.												
05													
06	Systems Integration Anal. of												
07	Candiate LRB Designs												
08													
09	LRB Programmatics Anal.												
10													
11	Flight Planning/Mission												
12	Operations Anal.												
13													
14	Aero Loads Anal.												
15													
16	Aero Database Mod.												
17													
18	Phase A Design Contractors												
19	- Configuration Definition												
20	- System Definition												

Note:

Johnson Space Center - Houston, Texas

LRB/STS SYSTEMS INTEGRATION

Advanced Programs Office

J.B. McCurry/LEMSCO | 12/16/87

J.B. McCurry
APPROVAL M.A. Culp
ACCOMP.

JSC INTEGRATION TASK, FY 1988

Page 2 of 3

ORIG. APPVL. 11/24/87
LAST CHANGE 12/02/87
STATUS AS OF 12/02/87

	MILESTONES	87 O	N	D	88 J	F	M	A	M	J	J	A	S
01	Vehicle Simulation Tool												
02	Modification/Verification												
03													
04	Hold-Down Launch Dynamics												
05	Anal.												
06													
07	Aero Heating Anal.												
08													
09	Separation Dynamics Anal.												
10													
11	Eagle Report Support												
12													
13	RI Integration Assessment												
14													
15	STSOC Facilities Resources												
16	Assessment												
17													
18	Phase A Design Contractors												
19	- Configuration Definition												
20	- System Definition												

Note:

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LRB/STS SYSTEMS INTEGRATION

Advanced Programs Office

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JSC INTEGRATION TASK, FY 1988

Page 3 of 3

ORIG. APPVL. 11/24/87
LAST CHANGE 12/02/87
STATUS AS OF 12/02/87

	MILESTONES	87			88								
		O	N	D	J	F	M	A	M	J	J	A	S
01	MMC ET Impacts Assessment							▽		▽			
02													
03	Phase A Integration Report						▽	▽		▽	▽		
04													
05	LRB Phase B RFP Development										▽		▽
06													
07	Launch Vehicle Input/Output										▽	▽	
08	Systems Anal. Template Dev.												
09													
10	LRB Applications Anal. for										▽		
11	Advanced Launch Vehicles												
12													
13	LRB Utilization Trade Studies										▽		
14													
15	SRB Utilization Design										▽		
16	Improvements												
17													
18	Phase A Design Contractors												
19	- Configuration Definition	▼				▽							
20	- System Definition					▽					▽		

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ASCENT PERFORMANCE TRENDS FROM PARAMETRIC STUDIES

- PROCEDURES
- TOOLS EMPLOYED
- SELECTED RESULTS

PERFORMANCE, COST AND TECHNOLOGY RISKS

- PERFORMANCE DEFINED BY MINIMUM REQUIREMENTS ON TWO POINT DESIGNS AT 28.5 DEGREE INCLINATION 150-NMI ORBIT
  --70K-LBM PAYLOAD AT 100% SSME THROTTLE
  --59K-LBM PAYLOAD AT 104% SSME THROTTLE

- COST REQUIREMENTS ARE BASED PREDOMINANTLY ON MINIMIZING COST PER FLIGHT AND DDT&E

- ADVANCED TECHNOLOGY TENDS TO DRIVE UP DDT&E WHILE COSTS PER FLIGHT ARE UNCERTAIN
  --THEN WHY CONSIDER ADVANCED TECHNOLOGY?

- POSSIBLE ADVANCED TECHNOLOGY PAYOFFS:
  --PROVIDING MORE BENIGN ORBITER ASCENT ENVIRONMENT (E.G. LOWER DYNAMIC LOADS, LESS FREQUENT SSME OVERHAUL, ETC.)
  --OPPORTUNITIES FOR SYSTEM GROWTH (E.G. NOMINAL REQUIREMENTS ACHIEVED WITH FUEL OFFLOAD, AND FLAT PERFORMANCE CURVES FOR ALTITUDE AND INCLINATION VARIATIONS)

- LOW TECHNOLOGY DISADVANTAGES:
  --POSSIBLE COMBINATION OF DISADVANTAGES OF SOLIDS AND LIQUIDS
  --GROWTH MARGINS BECOME SMALLER

COMPUTER SIMULATIONS - 3 -DOF

LAUNCH

- Interactive, inputs adjust Shuttle or SDV SRB/LRB defaults
- Static thermodynamic engine analysis to determine liquid engine parameters by fuel type, mixture ratio, chamber pressure and nozzle expansion with one dimensional equilibrium flow calibrated with recent design studies.
- 3-DOF trajectories, closed or open loop throttle and pitch profiles, iterative (3-5 trials) upper stage guidance based on analytical partials in earth relative frame to minimum fuel target (h, v, γ).

Reference: AIAA 83-1189, W. Kelly

P3DLN

- Interactive, inputs adjust shuttle or other vehicle defaults.
- Fewer engine analysis features than LAUNCH program
- More comprehensive and accurate trajectory and targeting with rapid convergence in inertial frame, analytical partials for choices among 13 target parameters.
- Applications: dog-leg ascent maneuvers west coast launches, winds and no winds effects.

Reference:

MSFC TMX-53464, 25 May 1966, L. R. Dickey

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LRB PERFORMANCE CALCULATION RUDIMENTS

$m_{MECO}/m_{ig} = \exp(-\Delta v_{ideal}/g\ Isp_{eff})$

$\Delta v_{ideal} = f(v_I, v_o, \Delta v_{grav}, \Delta v_{eng}, \Delta v_{drag}, \Delta v_{tvc}) = v_I - v_o + \Sigma\Delta v_i$

$v_I = 25{,}680$ fps $\quad v_o = 1337$ fps. $\quad \Delta v_{grav} > 4000$fps $\quad \Delta v_{ideal} > 29000$

$\Delta v_{ideal} = \Delta v_{ideal\text{-}1} + \Delta v_{ideal\text{-}2}$ $\quad \Delta v_{ideal\text{-}2} > 20{,}000$ fps.

$m_{MECO}/m_{sep-} = \exp(-\Delta v_{ideal2}/g\ Isp_{SSME's})$ $\quad (T/W)_{sep-} > 1.0$

(3*SSME*throttle)/wgt

$$=\underbrace{(m_{orb} + m_{pl} + m_{ET}}_{\text{fixed}} + \underbrace{m_{propmargin}}_{\text{variable}})/(\underbrace{m_{orb} + m_{pl} + m_{ET}}_{\text{fixed}} + \underbrace{m_{propsep}}_{\text{variable}})$$

$m_{sep^+}/m_{ig} = \exp(-\Delta v_{ideal\text{-}1}/g\ Isp_{av})$

$$= (m_{orb} + m_{pl} + m_{ET} + m_{prop\text{-}sep} + m_{srb/lrb})/(m_{orb} + m_{pl} + m_{ET} + m_{prop} + m_{srb/lrb} + m_{prop\text{-}boosters})$$

$(T/W)_{ig} > 1.1$ or 1.2 $\quad Q_{max} > 700$ or 750 psf.

Bottom line:
Most of the ideal velocity adjustments possible in the LRB study will come from the LRB selection itself.

ASCENT PERFORMANCE TRENDS	Advanced Programs Office	
	W.Kelly/LEMSCO	9/30/87

INTRODUCTION TO PLOTS OF PERFORMANCE TRENDS

- THE MAJORITY OF FIGURES WERE GENERATED WITH LAUNCH PROGRAM ON IBM-COMPATIBLE PC WITH LOTUS 1-2-3 PLOT PACKAGE
- THE AIM OF THE PROGRAM: TO CONNECT SIMPLE TRAJECTORY, GUIDANCE AND ENVIRONMENT MODELS WITH SIMPLE PROPULSION, STRUCTURES AND OTHER DESIGN FORMULATIONS IN A PRELIMINARY DESIGN SCHEME
- WHILE LAUNCH SIMULATIONS ARE ACKNOWLEDGED AS ONLY CUTS ABOVE STATIC CALCULATIONS, THE PROGRAM CAN ACT AS A FIRST PASS FILTER FOR CONFIGURATIONS BEFORE MORE DETAILED MODELING
- TRAJECTORY AND PARAMETRIC PLOTS DISPLAY DATES GENERATED (JULY-SEPTEMBER 87) TO TRACK
  --SIMULATION FEATURES, INPUT AND OUTPUT CORRECTIONS
  --METHOD USED TO DETERMINE MINIMUM LRB PERFORMANCE REQUIREMENTS
- WHILE LITERAL ADAPTATION OF TRAJECTORY DATA DERIVED IN THESE BROAD ANALYSES COULD VIOLATE MANY STS CONSTRAINTS DISCUSSED ELSEWHERE, IT IS POSSIBLE THAT MANY VIOLATIONS COULD BE ALLEVIATED IN SUBSEQUENT FOCUSED STUDIES

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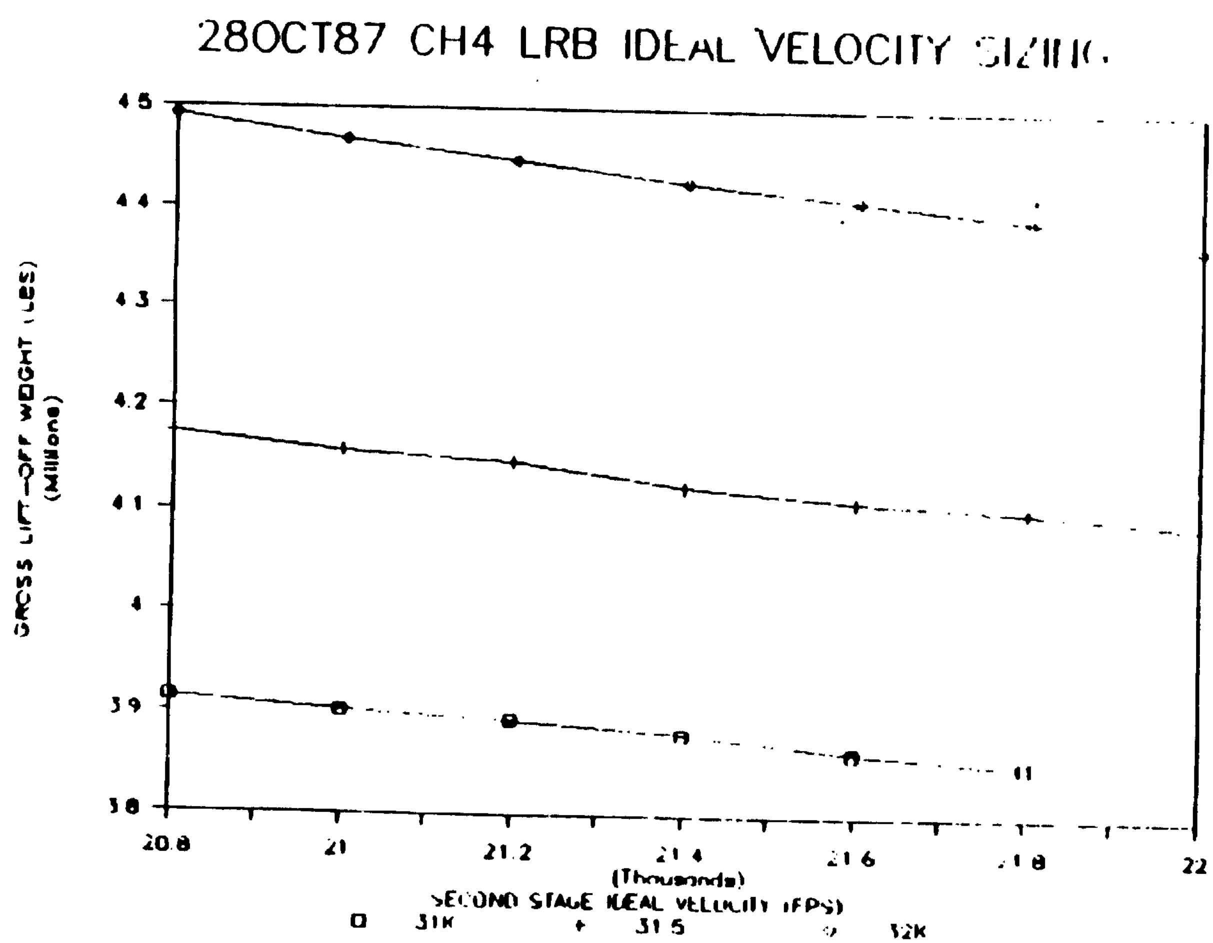
ASCENT PERFORMANCE TRENDS	Advanced Programs Office	
	W.Kelly/LEMSCO	9/30/87



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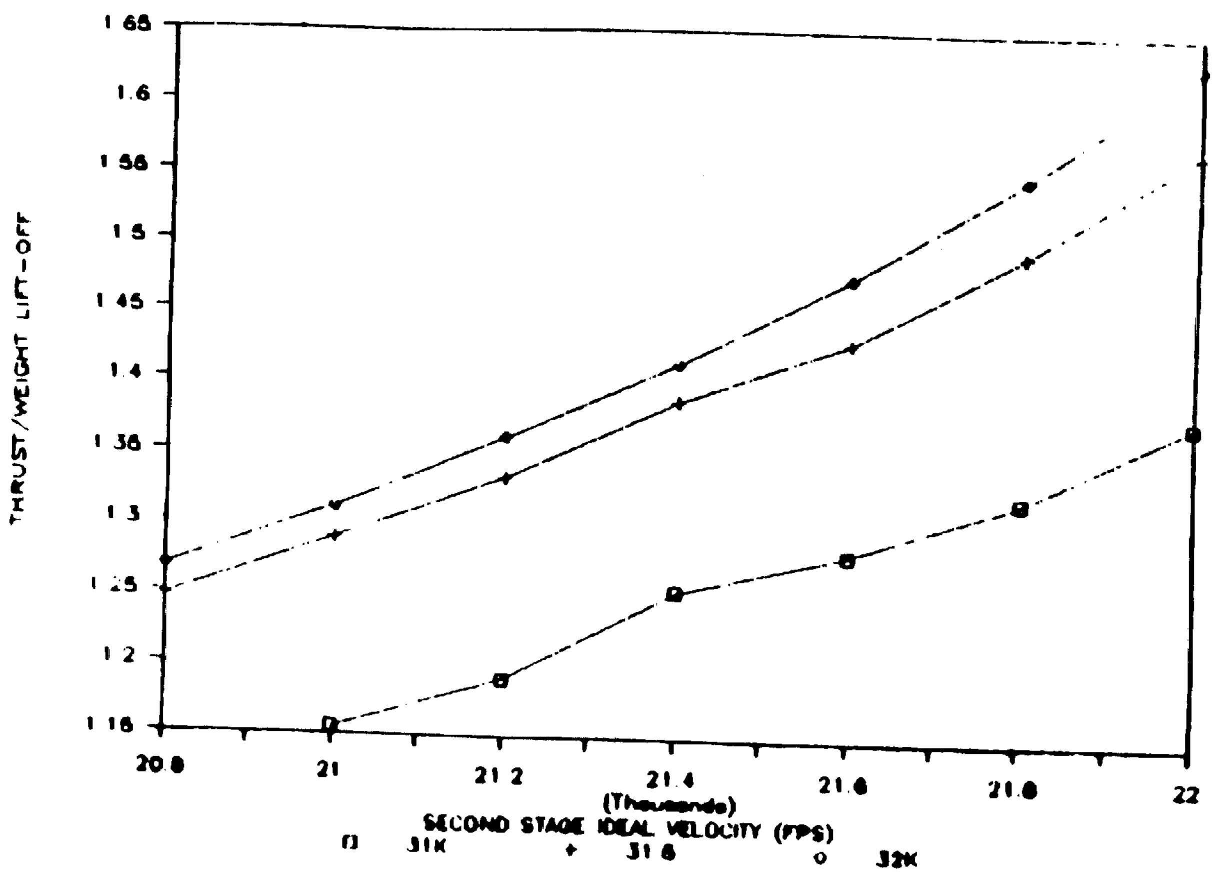
ASCENT PERFORMANCE TRENDS	Johnson Space Center - Houston, Texas	
	Advanced Programs Office	
	W.Kelly/LEMSCO	9/30/87

28OCT87 CH4 LRB IDEAL VELOCITY SIZING



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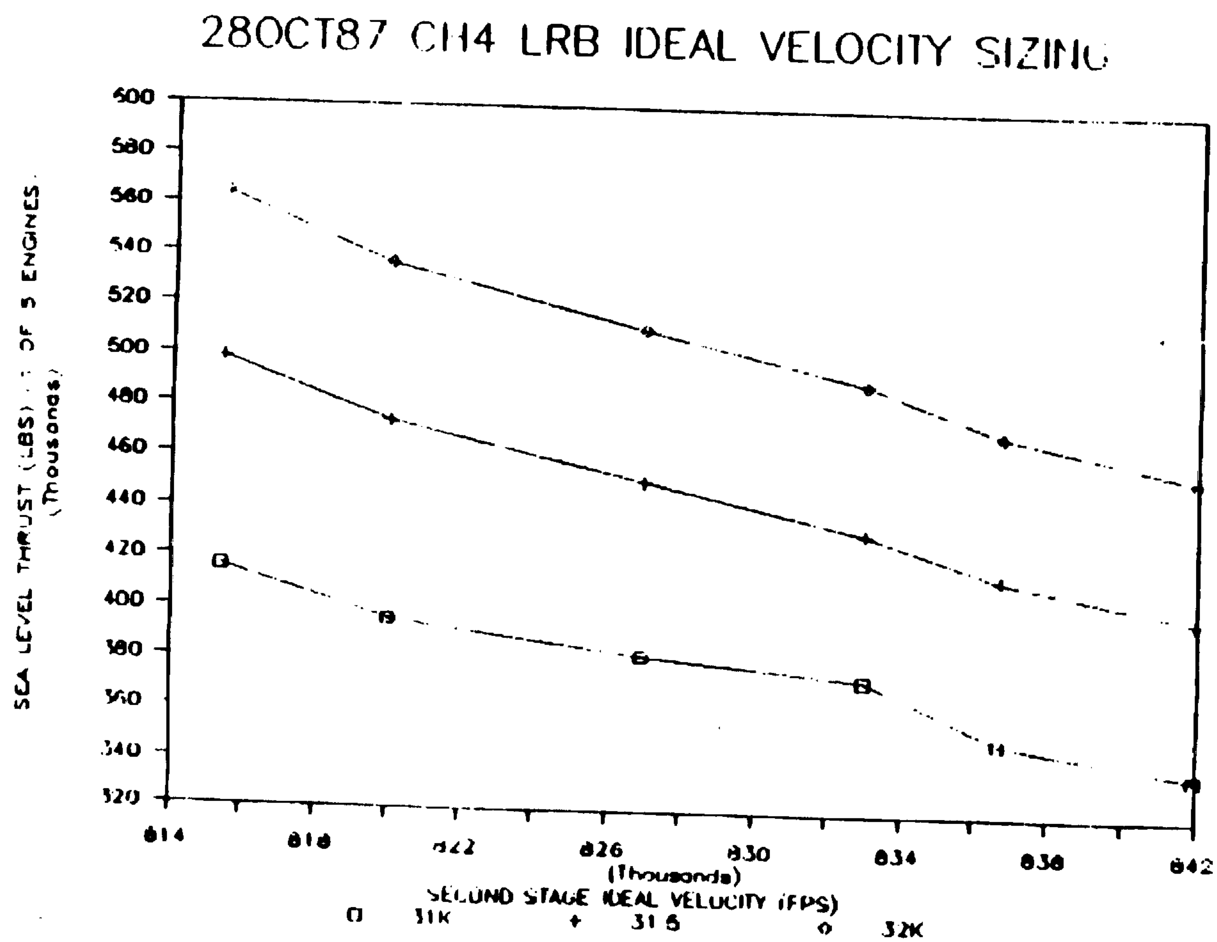
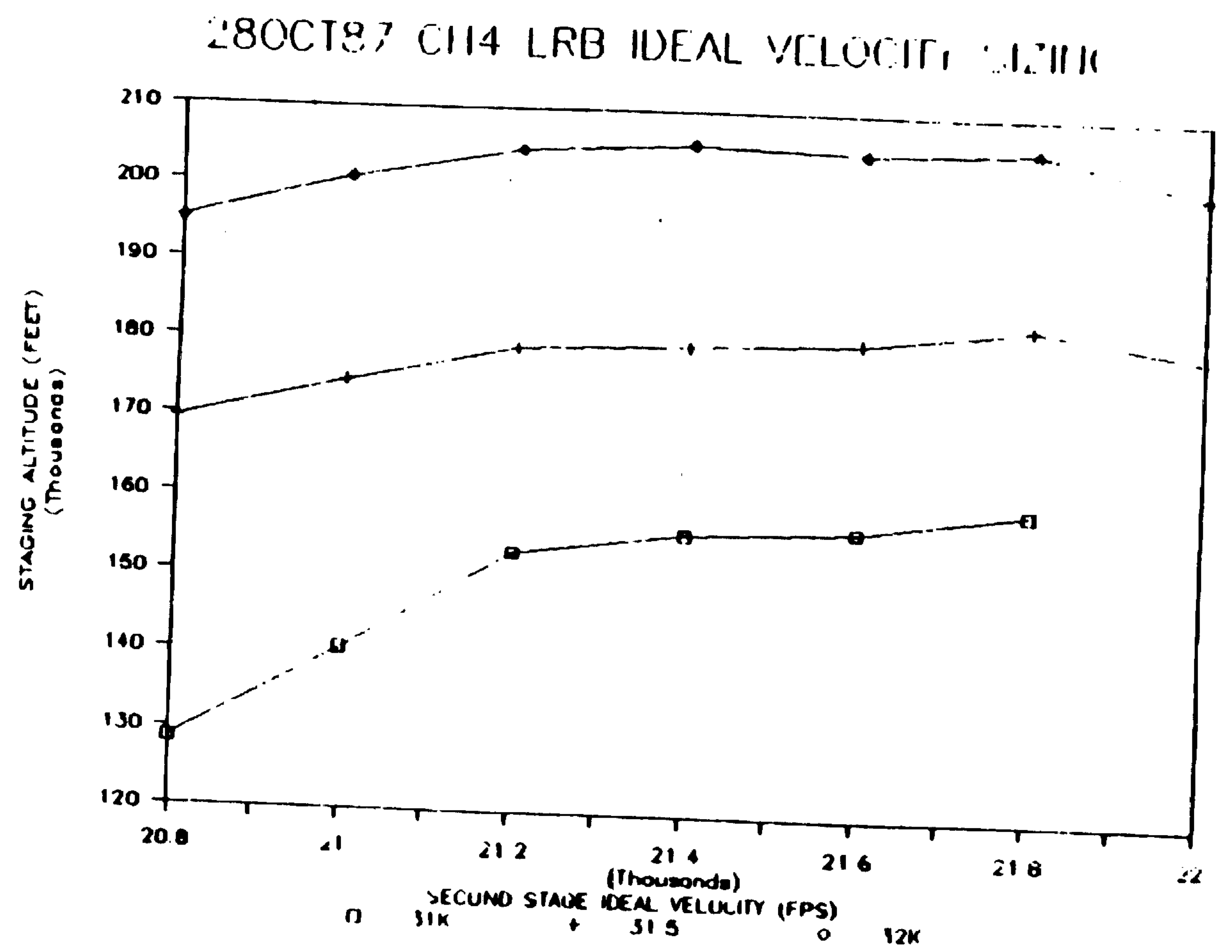

28OCT87 CH4 LRB IDEAL VELOCITY SIZING
SEA LEVEL THRUST (LBS) OF 5 ENGINES
(Thousands)
600
580
560
540
520
500
480
460
440
420
400
380
360
340
320
814
818
822
826
830
834
838
842
(Thousands)
SECOND STAGE IDEAL VELOCITY (FPS)
31K
31.5
32K



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ASCENT PERFORMANCE TRENDS

Advanced Programs Office

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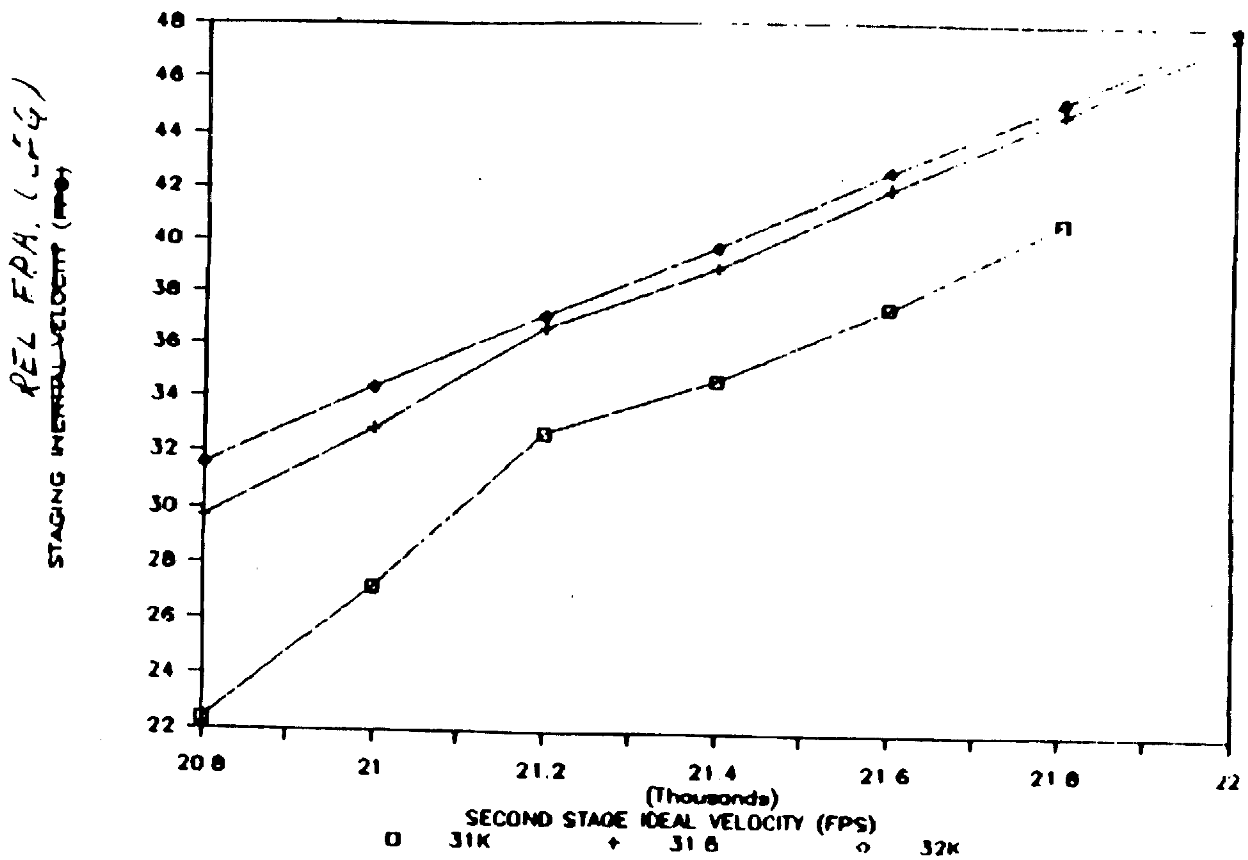
28OCT87 CH4 LRB IDEAL VELOCITY SIZING



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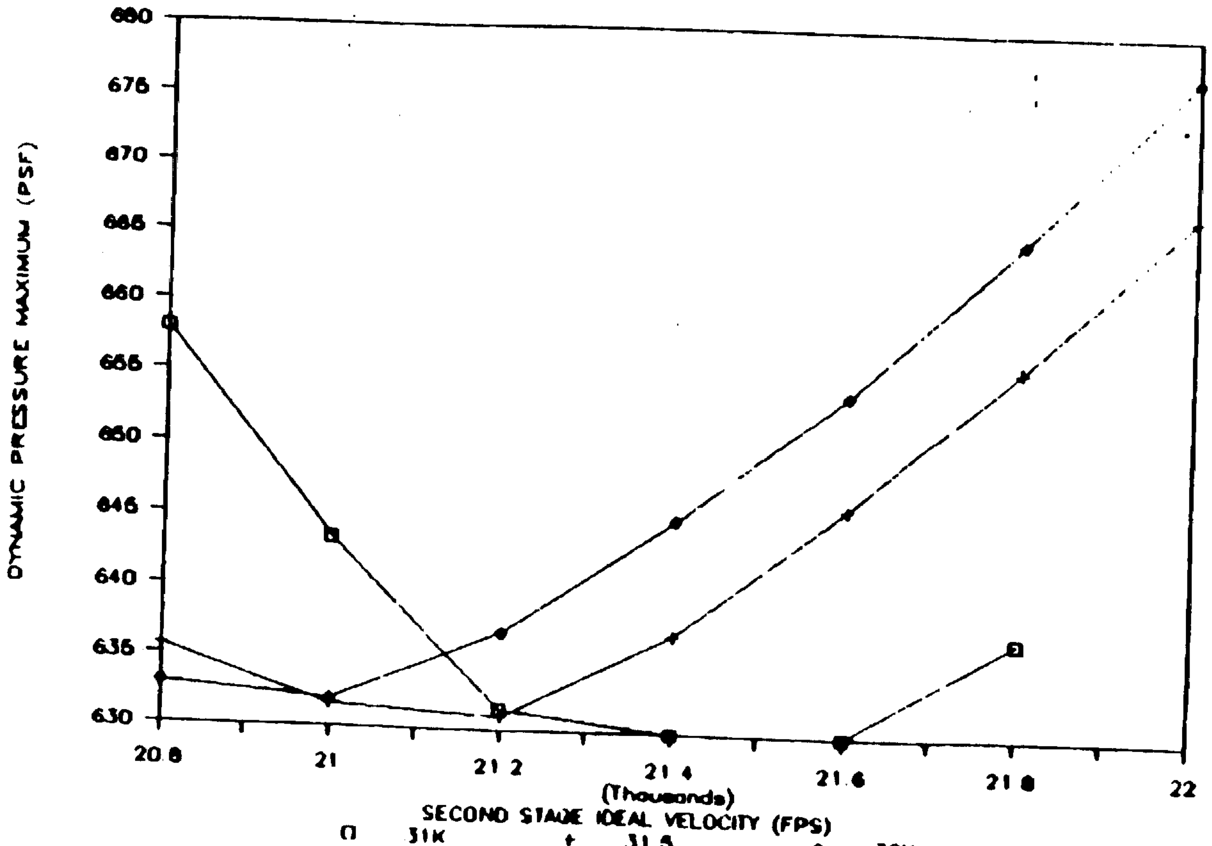
ASCENT PERFORMANCE TRENDS	Johnson Space Center - Houston, Texas	
	Advanced Programs Office	
	W.Kelly/LEMSCO	9/30/87

28OCT87 CH4 LRB IDEAL VELOCITY SIZING



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LRB ENGINE PERFORMANCE - ILLUSTRATIVE EXAMPLE

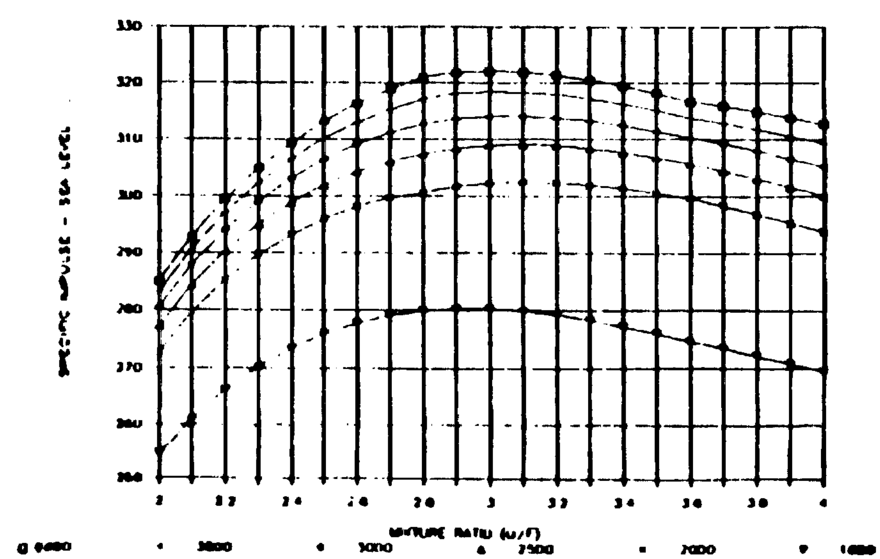
VARIED MIXTURE RATIO AND CHAMBER PRESSURE EFFECTS

LIQUID CH_4-O_2 5.5 PSI. FIXED EXIT PRESSURE

2.0 < MIXTURE RATIO < 4.0 1000 < P_c < 4000 psi.

Maxima

P_c	MR	Isp_{vac}	A_e/A_t	Isp_{sl}	Thrust 500-klb S.L. Diameter	Thrust Vacuum
1000	2.9	332	17	280	7.47-ft.	592860-lbf.
4000	3.0	360	55	322	7.15 -ft.	559000-lbf.



Johnson Space Center - Houston, Texas

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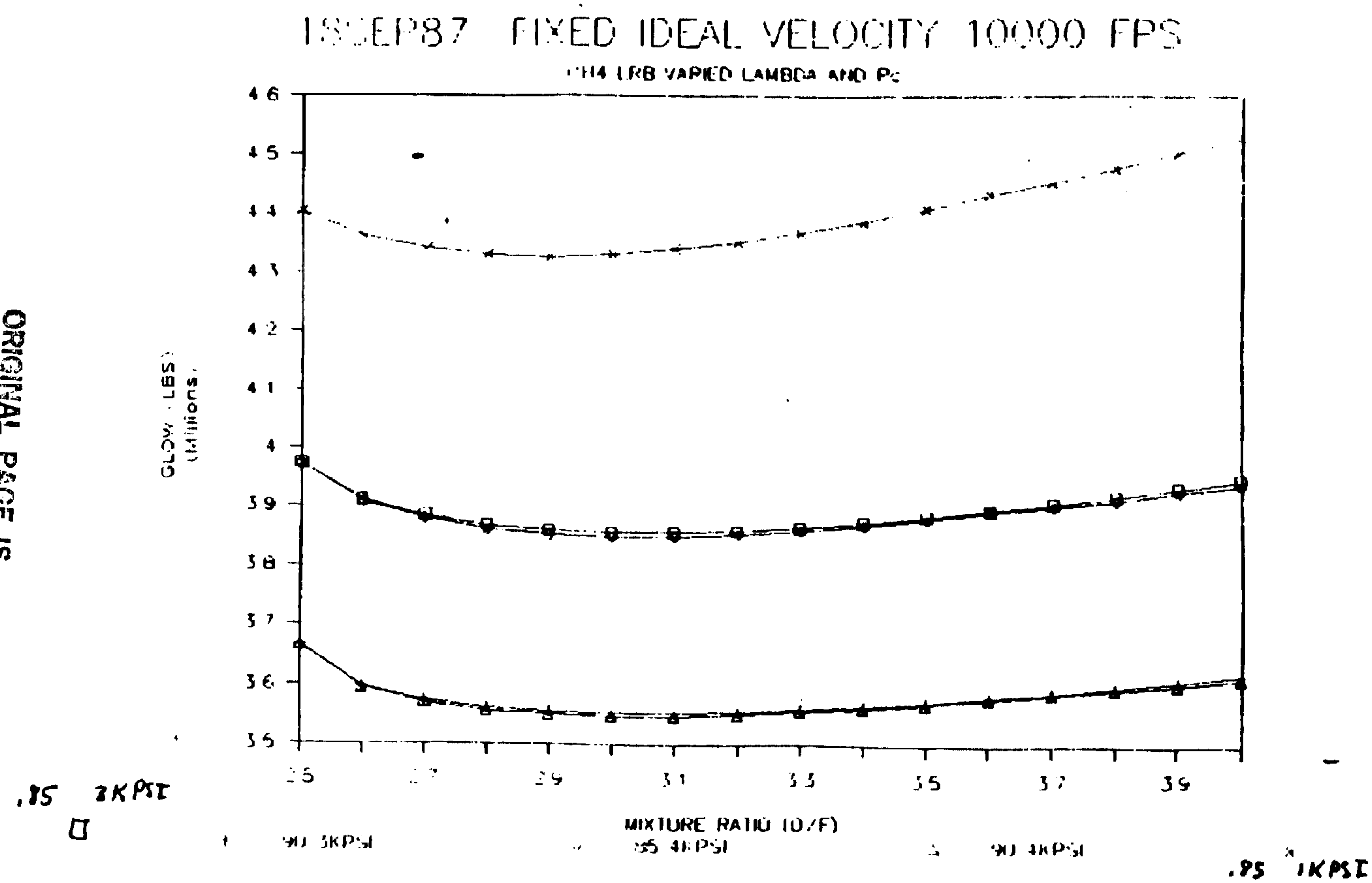
	W.Kelly/LEMSCO	9/30/87



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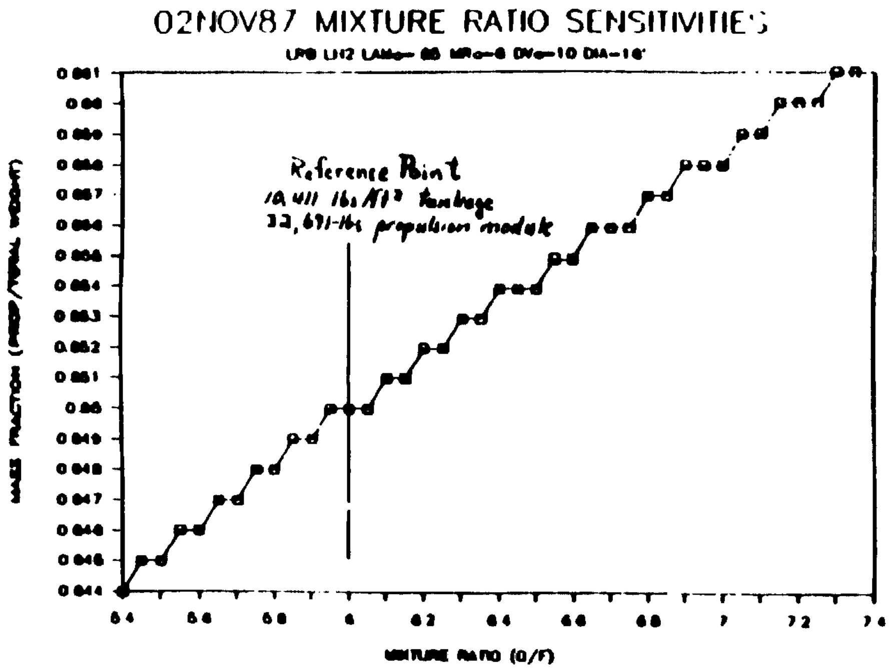
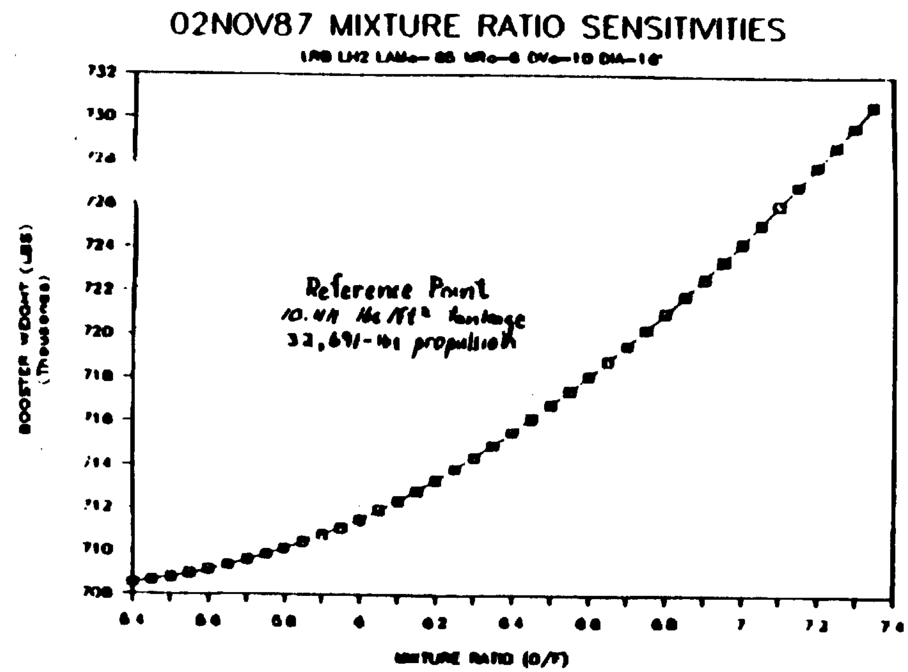
ASCENT PERFORMANCE TRENDS

Advanced Programs Office

W.Kelly/LEMSCO | 9/30/87





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C-2

SUMMARY AND CONCLUSIONS

- WITHOUT A DIRECTED SEARCH THROUGH PARAMETRIC BOOSTER CONFIGURATIONS, THE LIKELIHOOD OF DESIGNING A SATISFACTORY BOOSTER IS DECREASED.
- "LOW TECHNOLOGY" SRB EMULATORS CANNOT MEET SRB VOLUME LIMITS WITH LIQUID FUELS AND "HIGH TECHNOLOGY" (OR EXCESS LIFT) SOLUTIONS SHIFT TRAJECTORIES INTO NEW REGIONS.
- FOR PERFORMANCE ANALYSIS CONFIGURATION SEARCH TRADES CAN BE MADE ON LEVEL OF SIMULATION DETAIL VS. NUMBER OF CONFIGURATIONS STUDIED.

VOLUME IV

SECTION 2

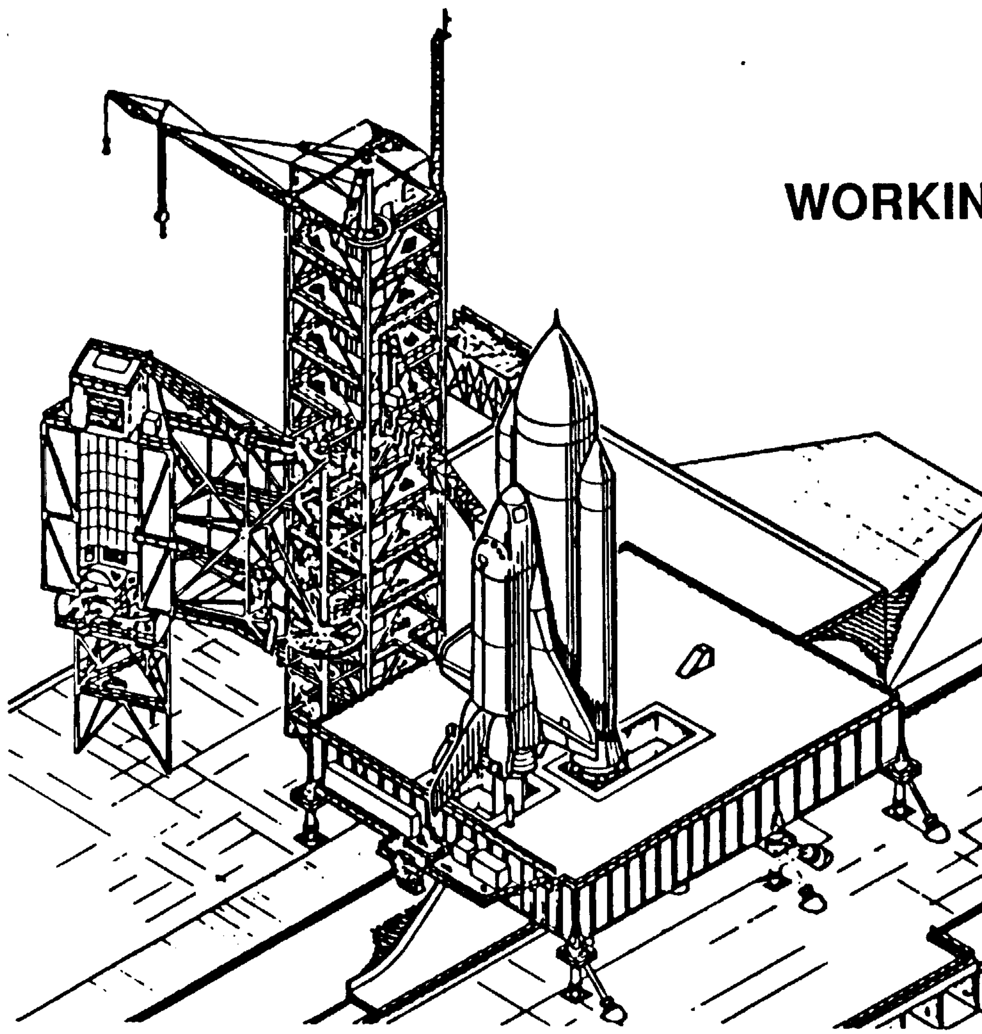
INTEGRATED WORKING GROUP MEETING

January 20, 1988

KSC ADVANCED PROJECTS & TECHNOLOGY OFFICE

LIQUID ROCKET BOOSTER (LRB) KSC IMPACT

JAN. 20, 1988
G. ARTLEY



TECHNICAL WORKING GROUP MEETING AT KSC

80113-01G

Lockheed Space Operations Company

KSC ADVANCED PROJECTS & TECHNOLOGY OFFICE

LIQUID ROCKET BOOSTER (LRB) KSC IMPACT

JAN. 20, 1988

AGENDA

• INTRODUCTION	GORDON ARTLEY
• BASELINE	L. PAT SCOTT
• REQUIREMENTS	R. KEITH HUMPHRYES / STEVE BLACK
• IMPACTS	GREGORY DEBLASIO / ROGER LEE
• SUMMARY	GORDON ARTLEY
• SPLINTER MEETING	JAN. 21, 1988 1430 HRS

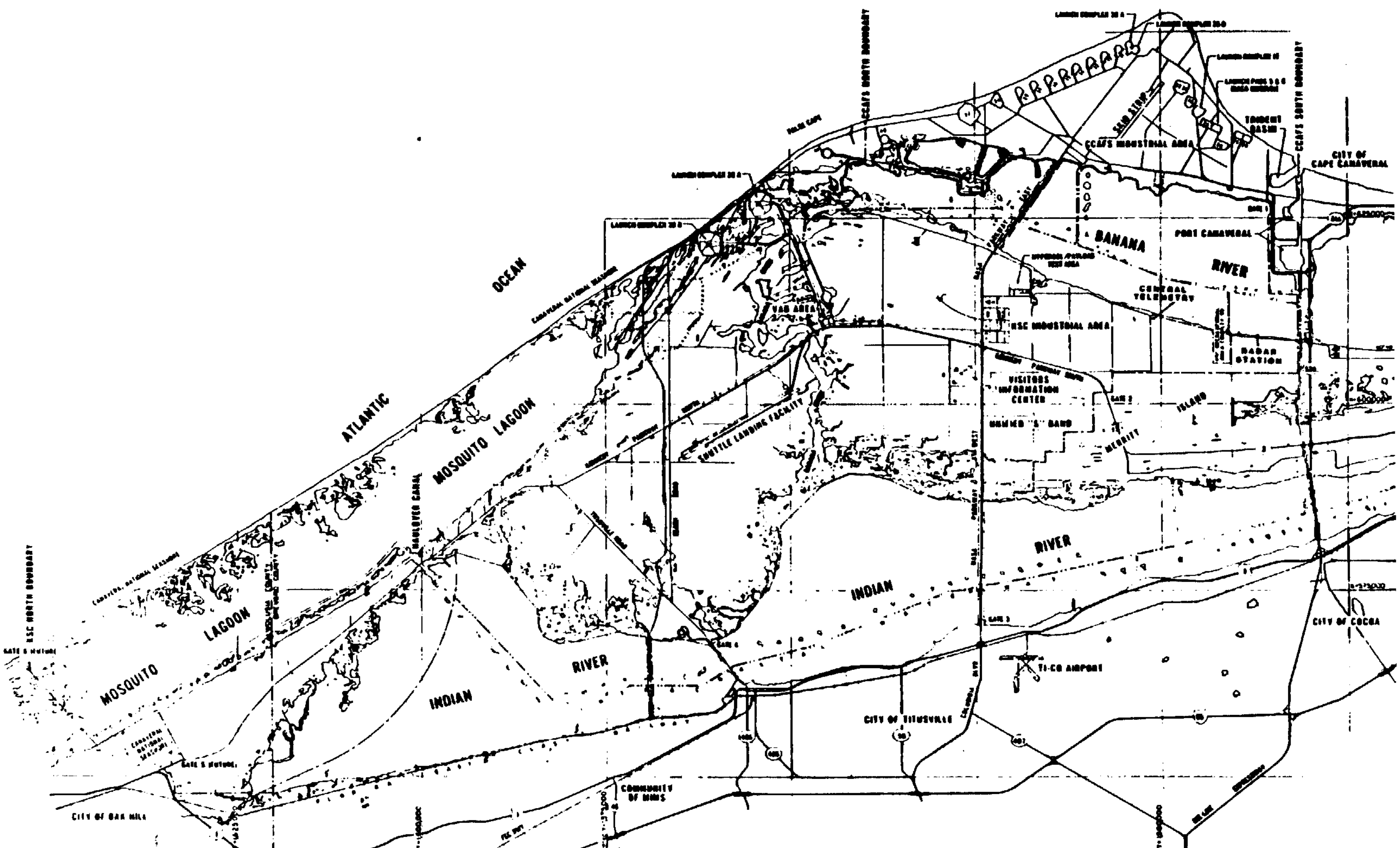
80113-01F1

Lockheed Space Operations Company

KSC ADVANCED PROJECTS & TECHNOLOGY OFFICE

LIQUID ROCKET BOOSTER (LRB) INTEGRATION STUDY

JAN. 20, 1988
G. ARTLEY



JOHN F. KENNEDY SPACE CENTER AND CAPE CANAVERAL AIR FORCE STATION

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80113-01AE

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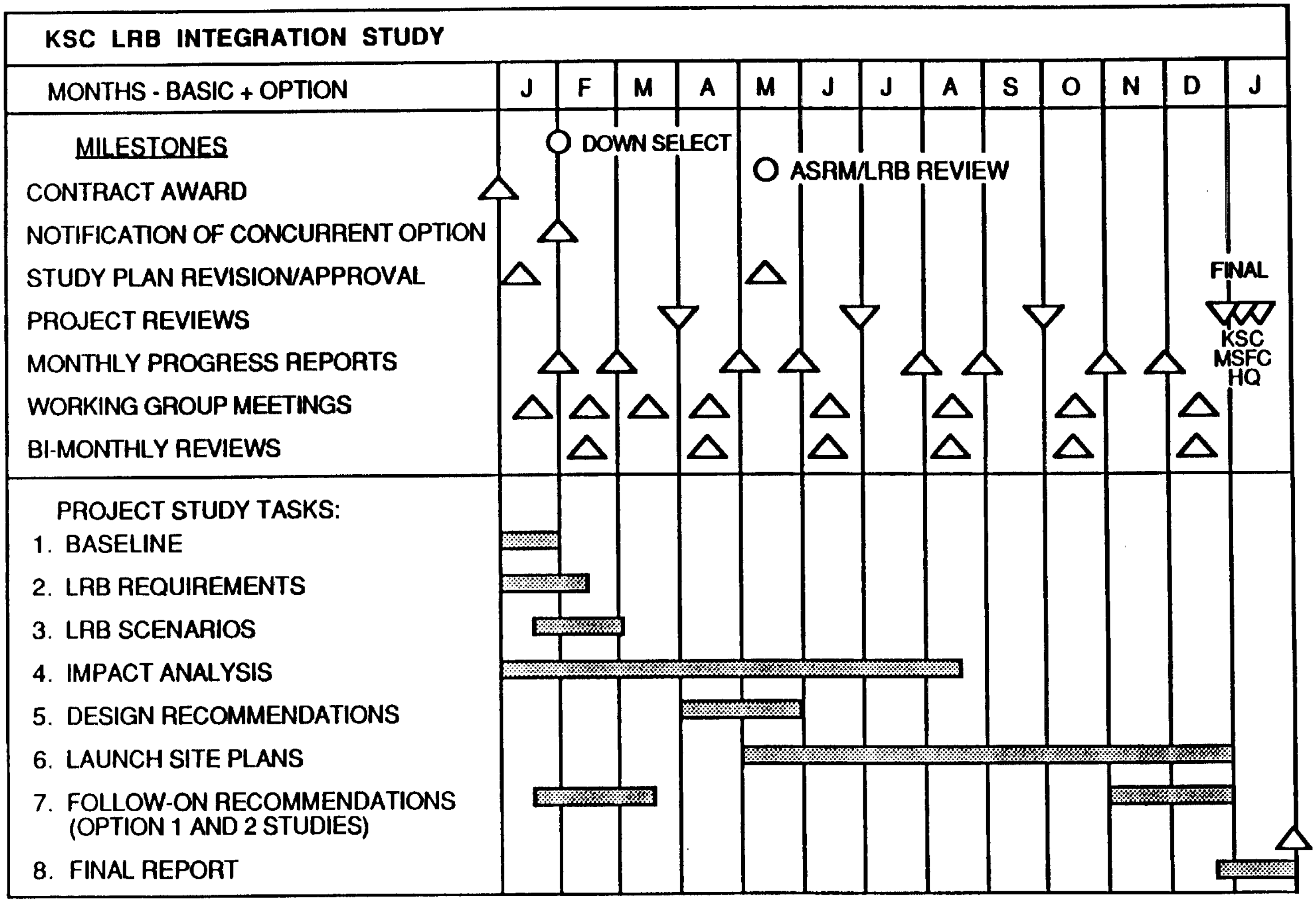
KSC ADVANCED PROJECTS & TECHNOLOGY OFFICE

LIQUID ROCKET BOOSTER (LRB) KSC IMPACT

JAN. 20, 1988
G. ARTLEY



LRB INTEGRATION SCHEDULE

80113-01J

Lockheed Space Operations Company

KSC ADVANCED PROJECTS & TECHNOLOGY OFFICE

LIQUID ROCKET BOOSTER (LRB) INTEGRATION STUDY

JAN. 20, 1988
G. ARTLEY

OBJECTIVES

- DEFINE SRB BASELINE
- DISCUSS LRB REQUIREMENTS/SCENARIOS
- IDENTIFY MAJOR LAUNCH SITE IMPACTS

Lockheed Space Operations Company

LIQUID ROCKET BOOSTER (LRB) KSC IMPACT

JAN. 20, 1988

AGENDA

• INTRODUCTION	GORDON ARTLEY
• BASELINE	L. PAT SCOTT
• REQUIREMENTS	R. KEITH HUMPHRYES / STEVE BLACK
• IMPACTS	GREGORY DEBLASIO / ROGER LEE
• SUMMARY	GORDON ARTLEY

SRB BASELINE

JAN. 20, 1988
P. SCOTT

TASK 1

OUTLINE

- SRB BASELINE FLOW OVERVIEW
- GENERIC SRB FLOW PROJECTED TO 1993
- MINI-SCHEDULES EACH SRB FACILITY
- SRB MULTIFLOW 93-94 TIME FRAME
- FACILITY PLANNING/UTILIZATION/CONSTRAINTS
- GSE FOR SRB PROCESSING/OMI PROCEDURES
- TRANSITION PLANNING (94-98)

RATIONALE FOR SRB BASELINE EVALUATION

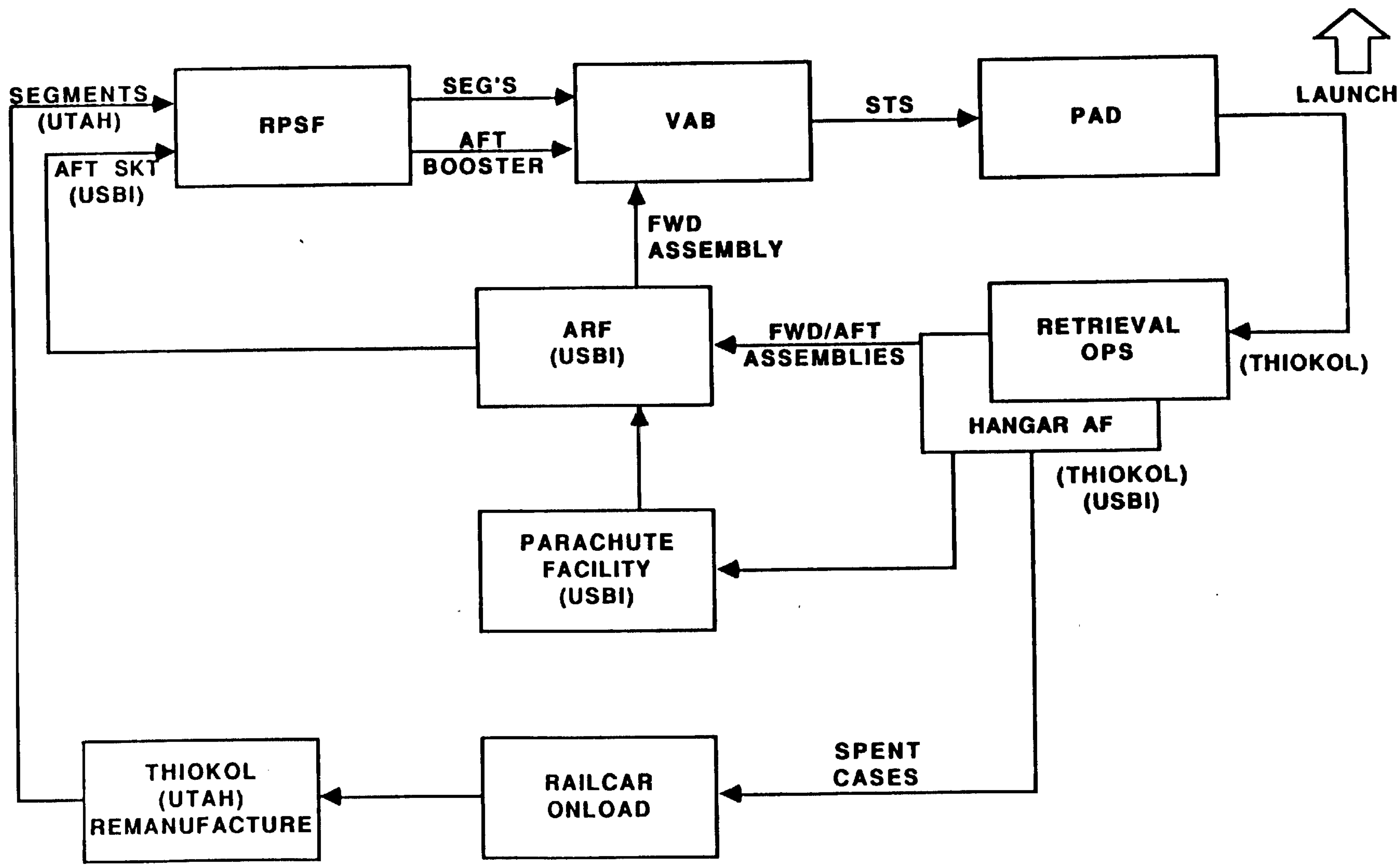
JAN. 20, 1988
P. SCOTT

- BASIS FOR:
  - COST DELTAS AND MANPOWER ASSESSMENTS
  - FACILITY EVALUATIONS (INCLUDING MODS)
  - TRANSITION PLANNING (FOR MIXED FLEET OPS)
  - DEVELOPMENT OF LRB FLOW SCHEDULES

KSC ADVANCED PROJECTS & TECHNOLOGY OFFICE

BASELINE SRB PROCESSING

JAN. 20, 1988
P. SCOTT



80113-01M

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K S C ADVANCED PROJECTS & TECHNOLOGY OFFICE

LIQUID ROCKET BOOSTER (LRB) INTEGRATION STUDY

JAN. 20, 1988
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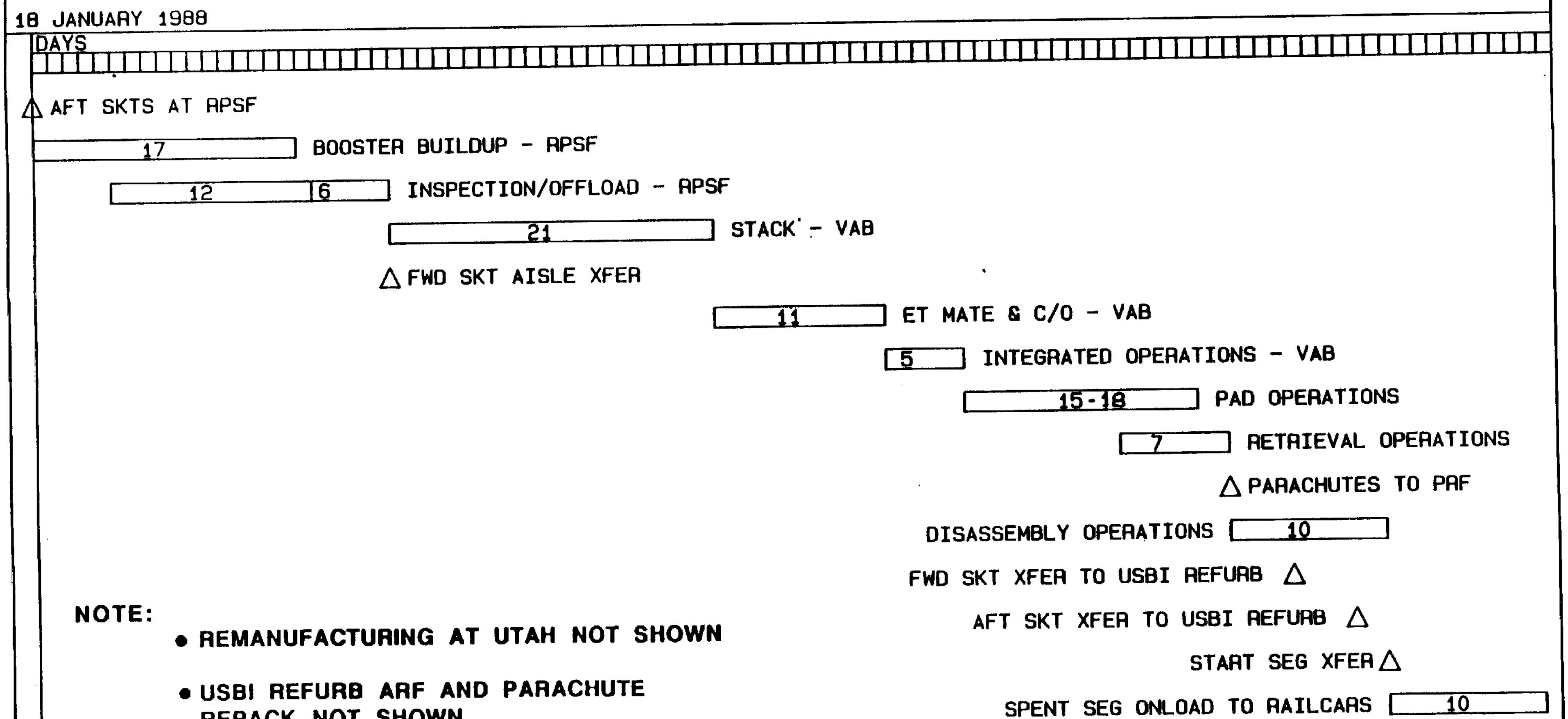
1994 SRB PROCESSING BASELINE SUMMARY
(97 DAY FLOW)



NOTE:
- REMANUFACTURING AT UTAH NOT SHOWN
- USBI REFURB ARF AND PARACHUTE REPACK NOT SHOWN

Page 1 of 1

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K
S
C

ADVANCED PROJECTS
& TECHNOLOGY OFFICE

LH/RH AFT BOOSTER BUILD UP

JAN. 20, 1988
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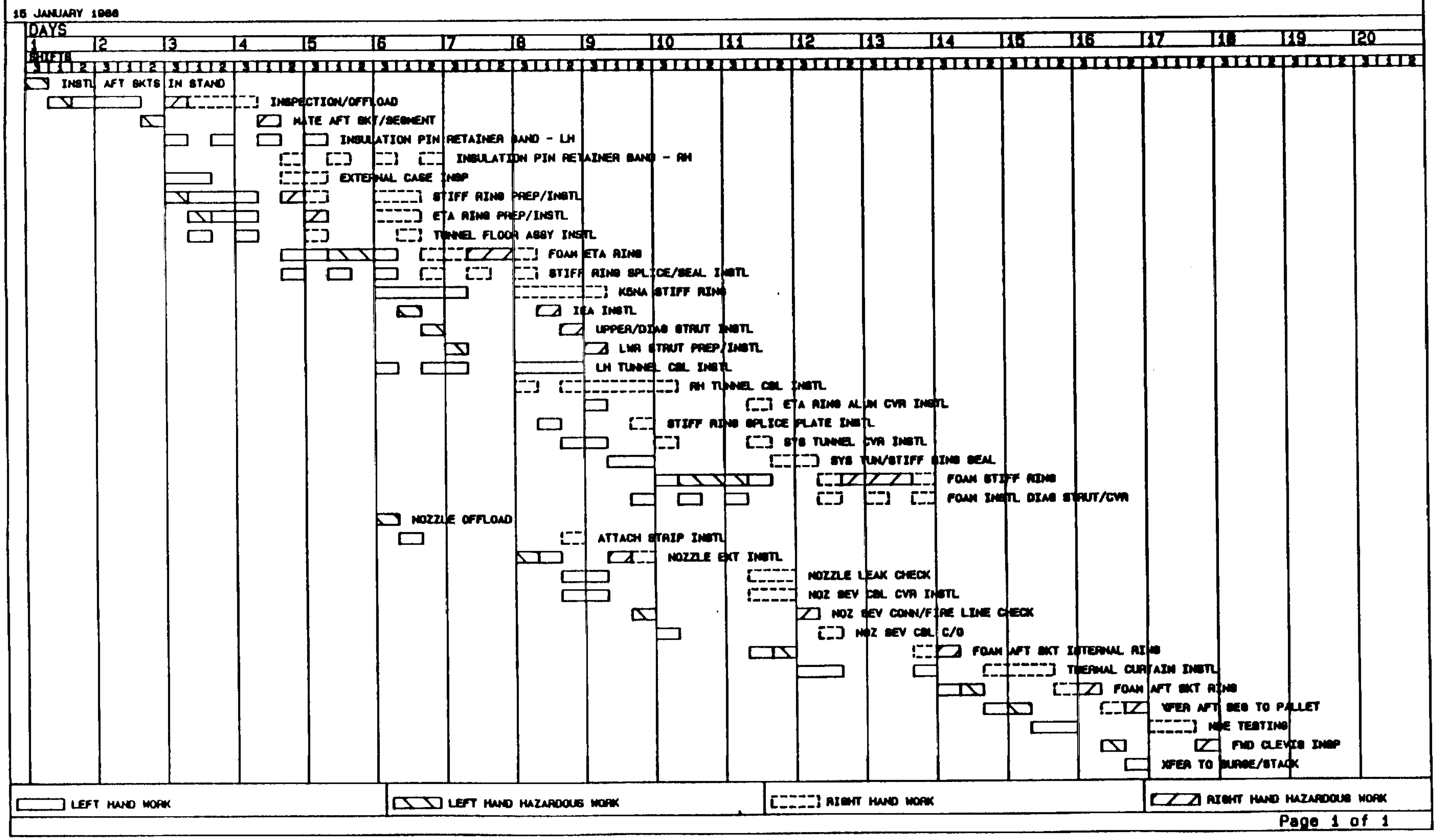
SRB BOOSTER BUILDUP BASELINE FOR 1994
(17 DAY FLOW)



Page 1 of 1

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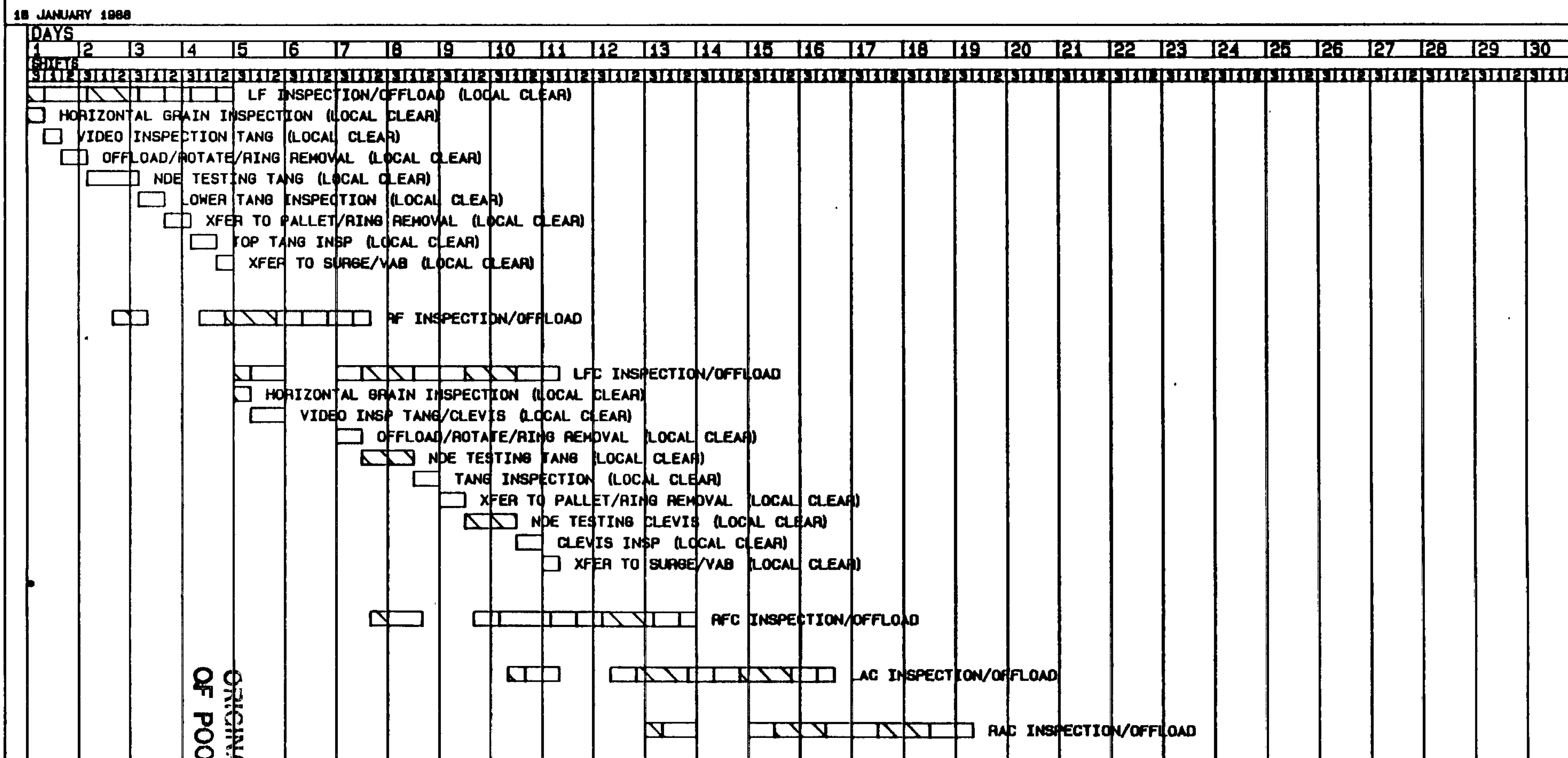
SRM SEGMENT OFFLOAD/INSPECTION

KSC ADVANCED PROJECTS & TECHNOLOGY OFFICE

JAN. 20, 1988
P. SCOTT

SRB INSPECTION/OFFLOAD BASELINE FOR 1994



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80113-01Q
7

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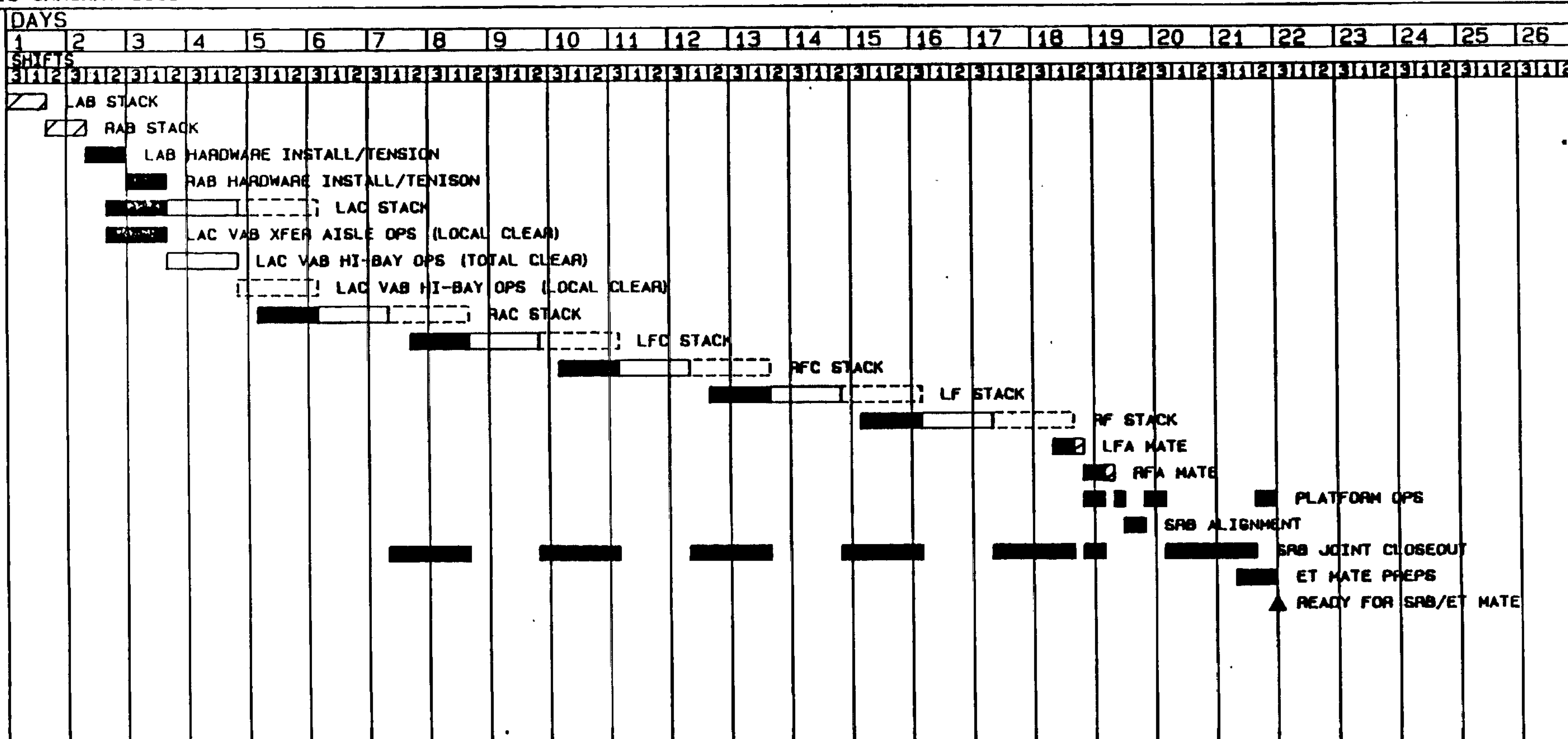
ADVANCED PROJECTS
KSC & TECHNOLOGY OFFICE

SRB STACKING/JOINT CLOSEOUT

JAN. 20, 1988
P. SCOTT

SRB STACK BASELINE FOR 1994

15 JANUARY 1988



XFER AISLE OPS	VAB HI-BAY OPS (TOTAL CLEAR)	VAB HI-BAY OPS (LOCAL CLEAR)	SRB JOINT CLOSEOUT
BEAM CONN/ADJUST TANG MEASURE/GREASE PROPELLANT SLUMP MEASURE J-SEAL PROFILE METAL PARTICLE INSP ENCLOSURE INSTL	DEPLOY ENCLOSURE/EST PURGE TANG/CLEVIS-CLEAN/REGREASE V2 FILLER/'O' RING INSTL APPLY J-SEAL ADHESIVE LEVEL SEG/MATE/PIN	J-SEAL INSPECTION JOINT LEAK CHECK	HEATER STRIP INSTL TEMP SENSOR INSTL WEATHER SEAL INSTL HEAT CONFIDENCE TEST CORK INSTL K5NA APPLICATION

Page 1 of 1

Lockheed
Space Operations Company

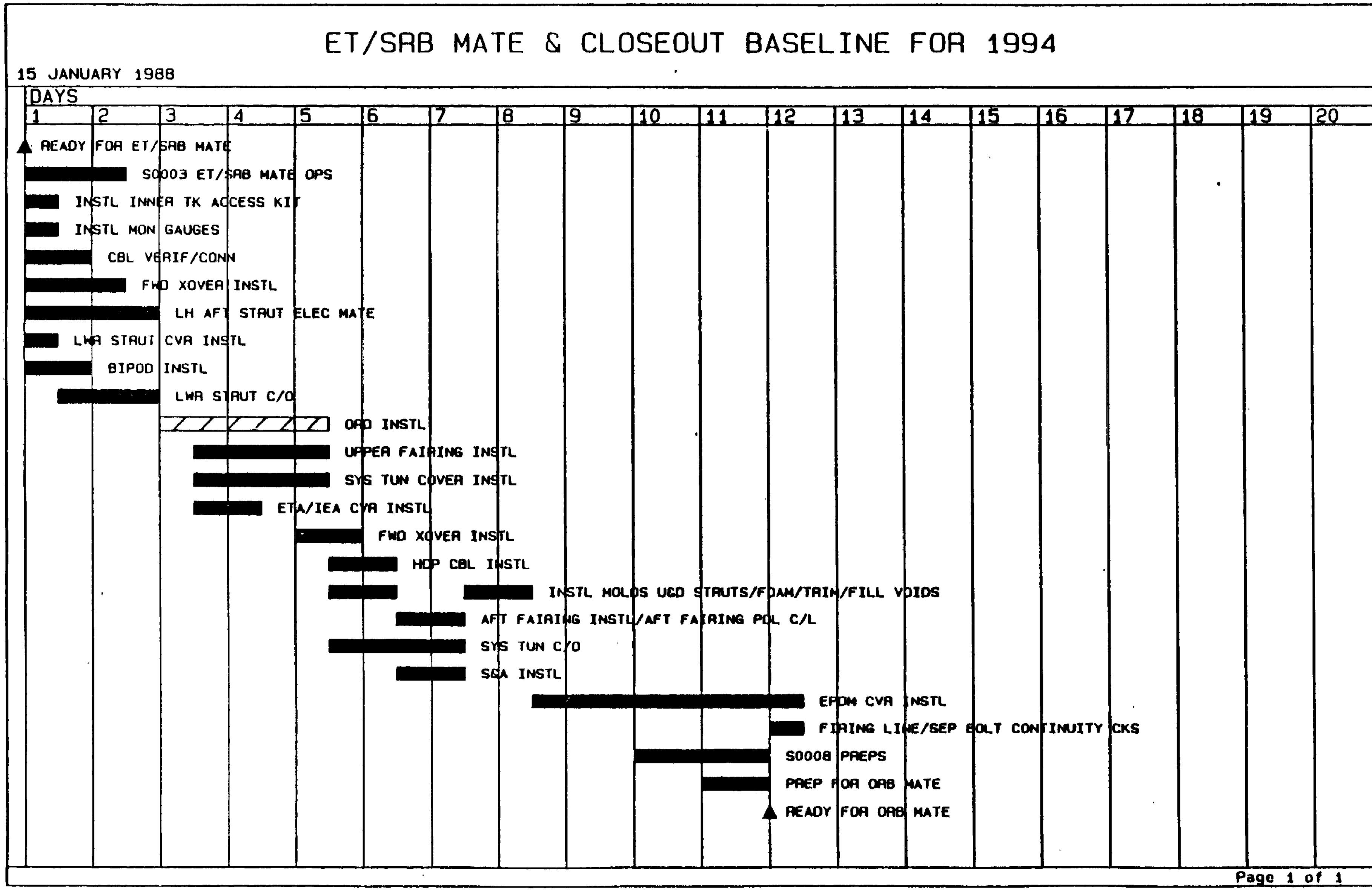
80113-01S

8

K S C ADVANCED PROJECTS & TECHNOLOGY OFFICE

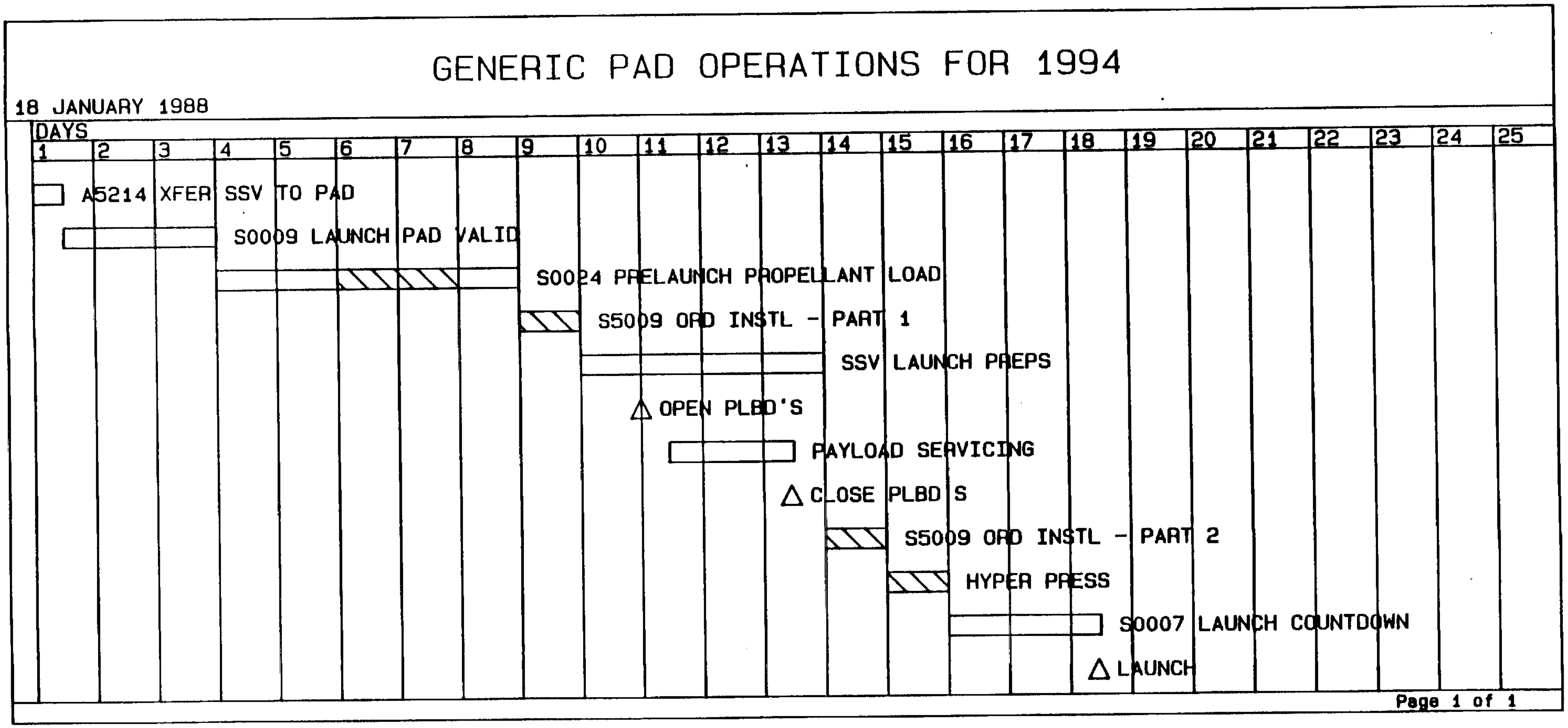
ET/SRB MATE & CLOSEOUT

JAN. 20, 1988
P. SCOTT



Space Operations Company

80113-011


GENERIC PAD OPERATIONS FOR 1994
18 JANUARY 1988
DAYS
1
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13
14
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16
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24
25
A5214 XFER SSV TO PAD
S0009 LAUNCH PAD VALID
S0024 PRELAUNCH PROPELLANT LOAD
S5009 ORD INSTL - PART 1
SSV LAUNCH PREPS
OPEN PLBD'S
PAYLOAD SERVICING
CLOSE PLBD S
S5009 ORD INSTL - PART 2
HYPER PRESS
S0007 LAUNCH COUNTDOWN
LAUNCH
Page 1 of 1

KSC ADVANCED PROJECTS & TECHNOLOGY OFFICE

SRB RETRIEVAL/DISASSEMBLY

JAN. 20, 1988
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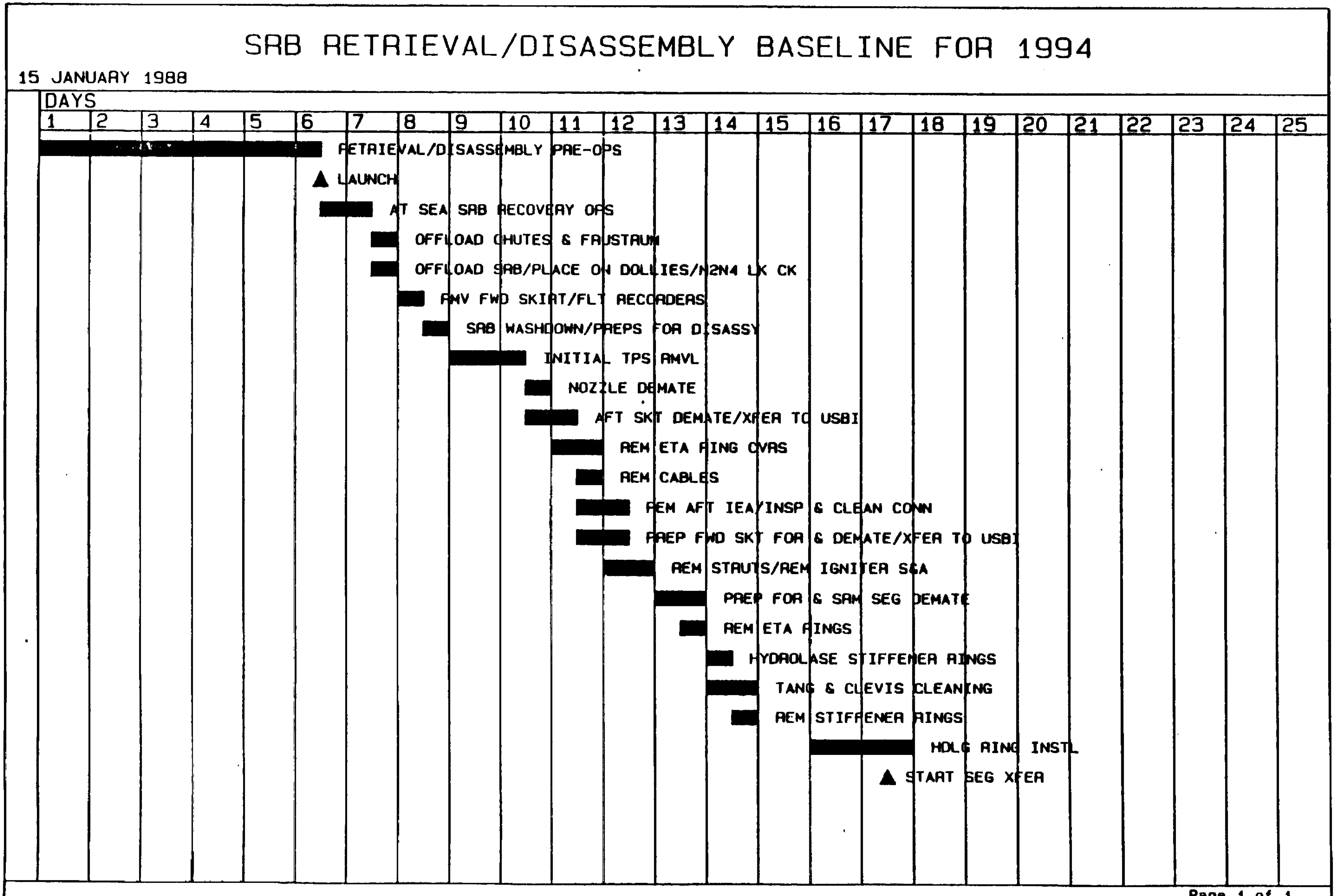
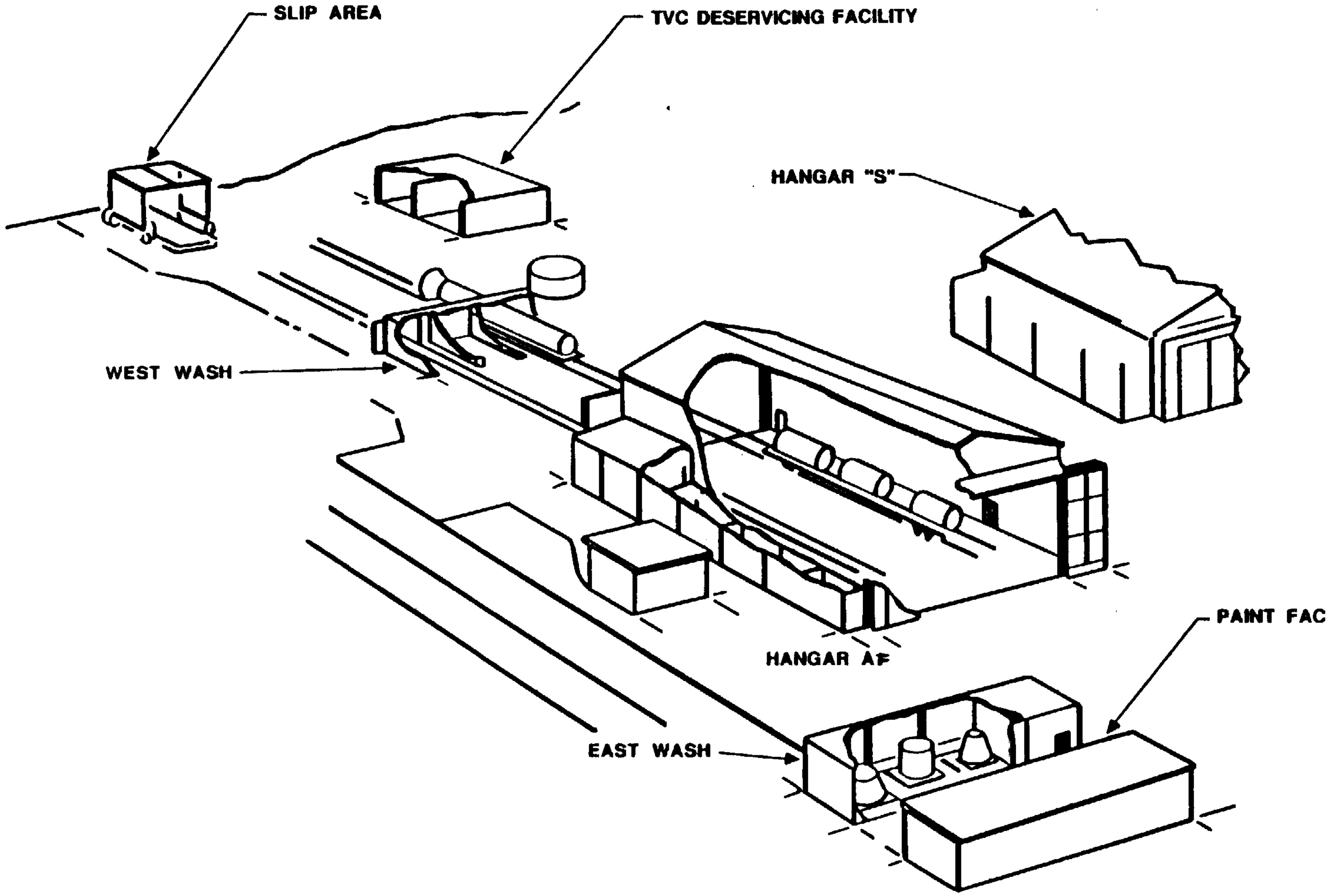


HANGAR AF/CCAFS FACILITIES FOR SRB DISASSEMBLY



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SRB MULTIFLOW '93-'94 TIMEFRAME

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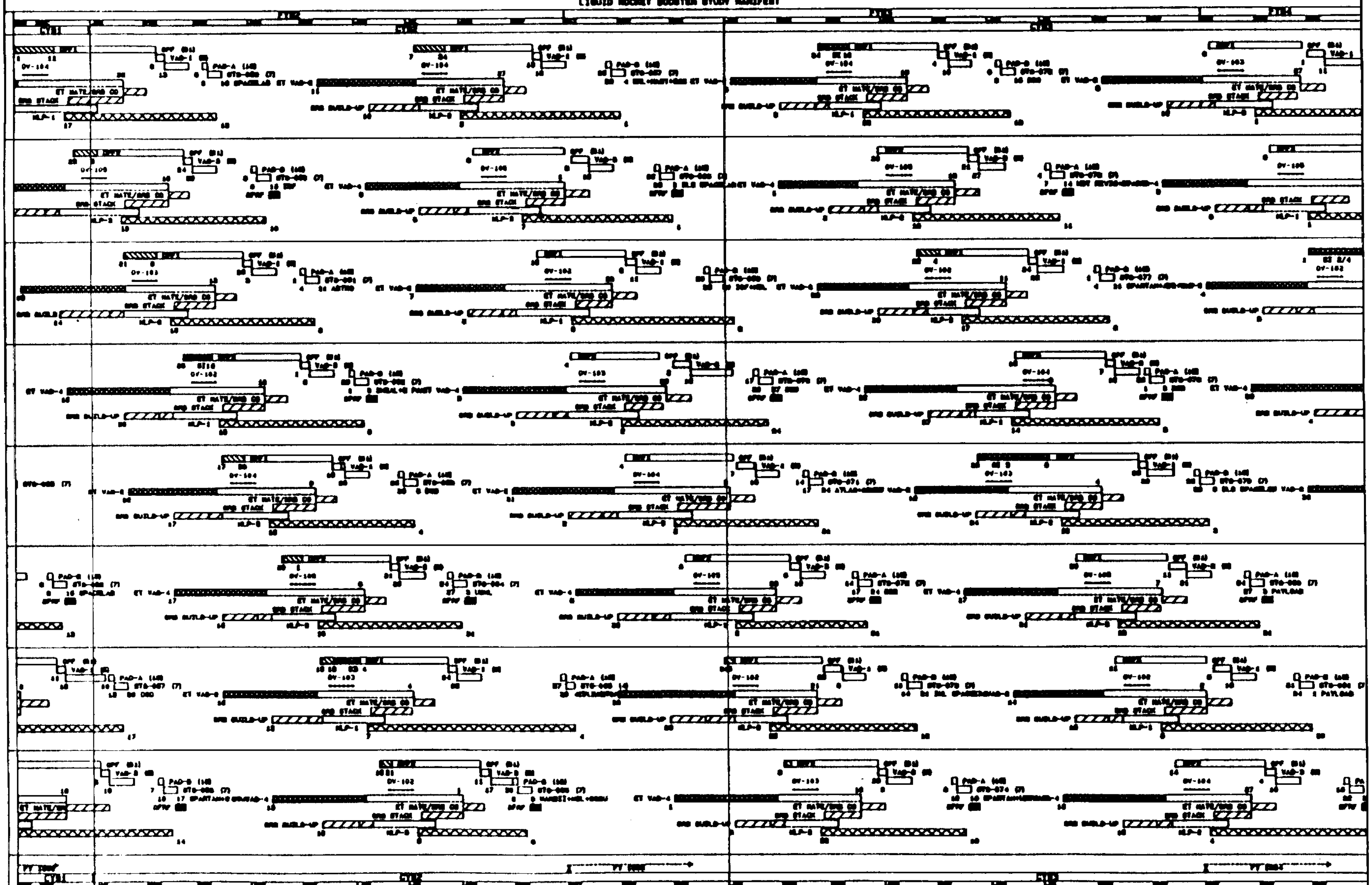
Lockheed Space Operations Company, Flight Requirements Planning & Control

FACILITY PLANNING CHART

PROGRAM CONTROLS

LIQUID ROCKET BOOSTER STUDY MANIFEST



PROCESSING LEGEND: ORBITER/SSV PROCESSING; ORBITER MODS/INSP, OMRF; ET PROCESSING; SRB PROCESSING; MLP UTILIZATION

ID: 120
PROJECT: LM800
FILE: LR6M8AR2

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Page 1 of 1

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SRB MULTIFLOW
'93-'94 TIMEFRAME

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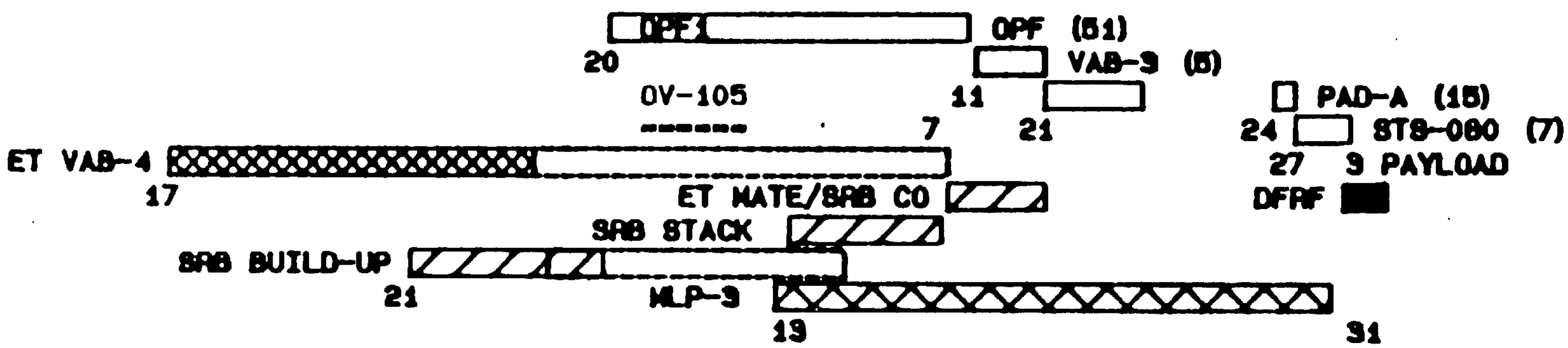

EXAMPLE MULTIFLOW (STS-080)
SEPT 1993 LAUNCH

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SRB FACILITY PLANNING/ UTILIZATION/CONSTRAINTS

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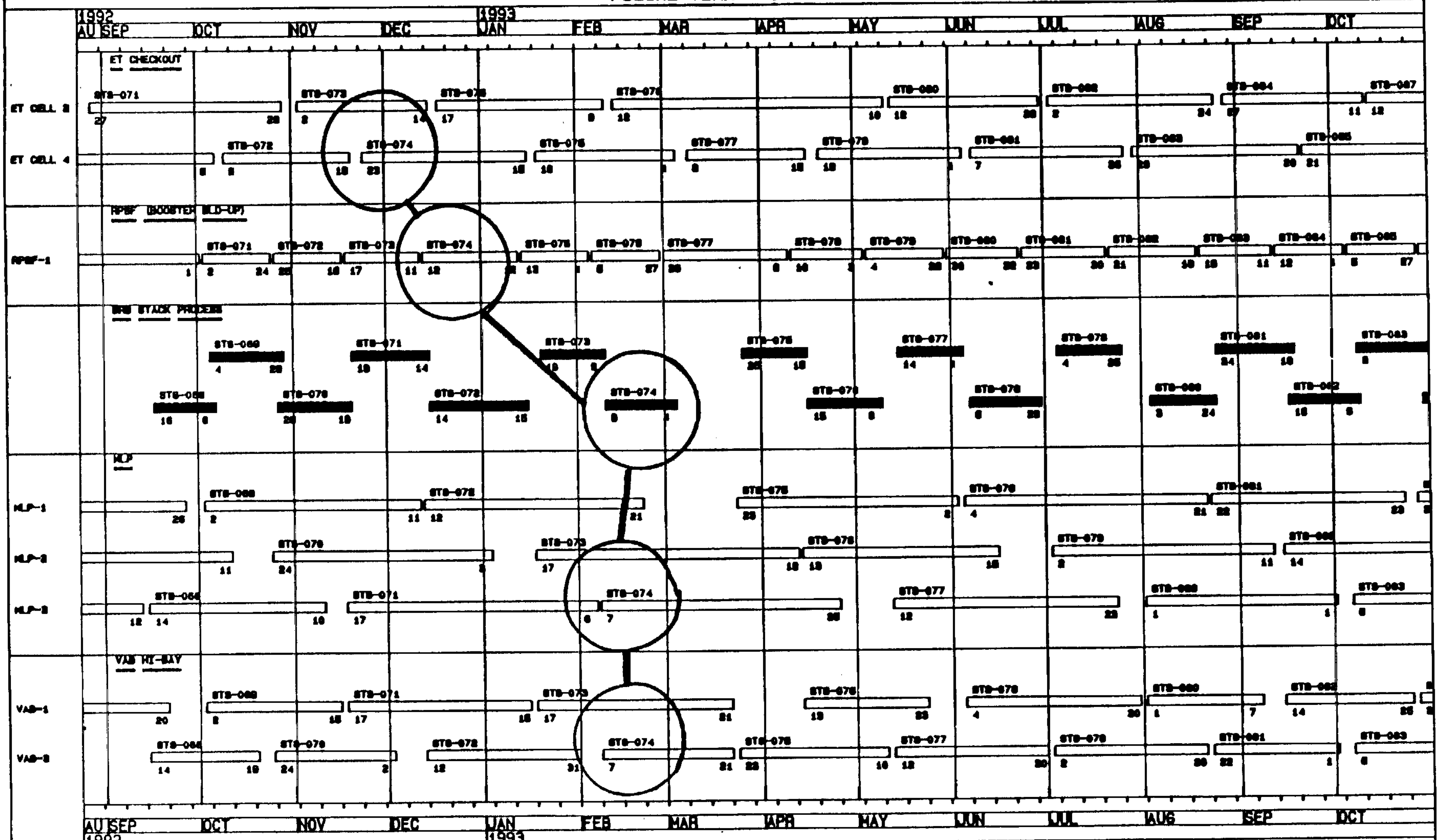
ET/SRB FACILITY UTILIZATION

FISCAL YEAR - 1993



PROJECT: LRBOA FROM 24-AUG-92 UNTIL 31-OCT-93
LOCKHEED FLIGHT REQUIREMENTS, PLANNING & CONTROL

ASSESSMENT BASED ON PRELIMINARY LIQUID ROCKET BOOSTER STUDY FLIGHT ASSIGNMENT MANIFEST FOR SPC PLANNING PURPOSES ONLY

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OMIs FOR SRB PROCESSING

- RPSF
  - B5308 - SRB ROTATION, PROCESSING AND SURGE FACILITY (RPSF) OPERATIONS
  - B5309 - AFT BOOSTER ASSEMBLY - RPSF
  - B5305 - AFT BOOSTER ASSEMBLY ELECTRICAL BUILDUP
- VAB
  - B5303 - STACKING AND ALIGNMENT OPERATIONS
  - B5307 - SRB CABLE INSTALLATION/CHECKOUT AND PRE-POWER ELECTRICAL CHECKS
  - B1009 - SRB TVC/GSE CONNECTION (VAB/PAD) - (LPS)
  - B1019 - SRB GSE HYDRAULIC SYSTEM DISCONNECT/CLOSEOUT
  - B7009 - SRB HOLDDOWN STUD TENSION INTEGRITY VERIFICATION
  - B5304 - SRB SYSTEMS INSTALLATION AND CLOSEOUT, PRE-ET MATE
- PAD
  - B1016 - SRB HYDRAZINE SERVICING
  - B2038 - HYDRAZINE SERVICE CART LOADING AND DRAIN
  - B1037 - SRB AFT SKIRT PURGE SYSTEM CONNECTION AND C/O
  - B2040 - SRB TVC/APU LUBE OIL SERVICE - PAD
  - B5306 - SRB POST-ET MATE AND PAD CLOSEOUT

LRB TRANSITION PLANNING

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	93	94	95	96	97	98	99
LRB #1	0	1	2	5	8	11	14
* LRB #2	0	3	6	9	12	14	
ASRM	0	4	8	12	14		
PLANNED SRB (MANIFEST)	12	14	14	14	14	14	14

ISSUES:

- IMPACTS TO ON-GOING LAUNCH OPERATIONS
- FACILITY/GSE ACTIVATION/MODS TO SUPPORT 94 LRB LAUNCH
- INTEGRATION OF LRB WITH OTHER PROGRAM CHANGES (STS-C, SPACE STATION, ETC)
- FULL ACTIVATION OF LRB SUPPORT SYSTEMS REQUIRED PRIOR TO INITIAL LAUNCH
- FEASIBILITY OF MIXED FLEET LAUNCHES

NEAR-TERM GOALS FOR BASELINE TASK

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- DEVELOP COSTS/MANPOWER PARAMETERS FOR BASELINE SRB FLOWS
- BEGIN LRB FLOW MODELLING
- INTEGRATE PHASE A CONTRACTOR DATA FROM DOWN-SELECT CHECKLIST
- EVALUATE ON-GOING LAUNCH IMPACTS

LIQUID ROCKET BOOSTER (LRB) KSC IMPACT

JAN. 20, 1988

AGENDA

• INTRODUCTION	GORDON ARTLEY
• BASELINE	L. PAT SCOTT
• REQUIREMENTS	R. KEITH HUMPHRYES / STEVE BLACK
• IMPACTS	GREGORY DEBLASIO / ROGER LEE
• SUMMARY	GORDON ARTLEY

LIQUID ROCKET BOOSTER (LRB) INTEGRATION STUDY

JAN. 20, 1988
K. HUMPHRYES

TASK II LRB REQUIREMENTS

APPROACH

- DEVELOP CHECKLIST
  - BY AREAS OF IMPACT
  - BY SYSTEM
- CHECKLIST TO PHASE A CONTRACTORS
  - EACH CANDIDATE CONFIGURATION
- ANALYZE CHECKLIST RESPONSES
  - COMMON
  - UNIQUE

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LIQUID ROCKET BOOSTER (LRB) INTEGRATION STUDY

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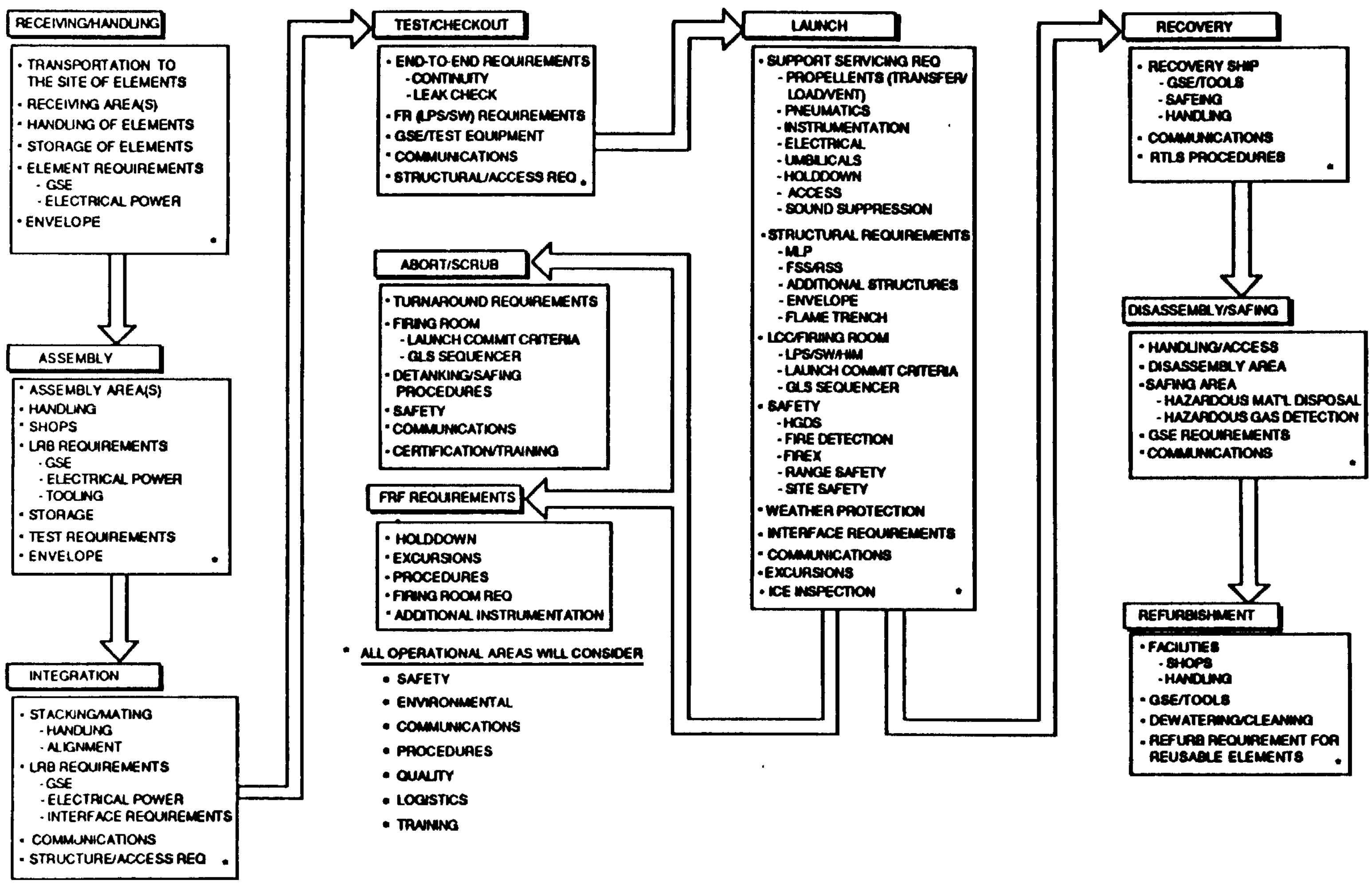

LRB CONFIGURATION EVALUATION AREAS OF IMPACT

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TYPICAL CHECKLIST ITEMS

- RECEIVING/HANDLING
  - HOW WILL BOOSTER/COMPONENTS ARRIVE?
  - WHAT SUPPORT EQUIPMENT WILL BE REQUIRED AT RECEIVING AREA?
- ASSEMBLY
  - WHAT LEVEL OF ASSEMBLY WILL BE REQUIRED AT LAUNCH SITE?
  - WHO WILL ACCOMPLISH ASSEMBLY?
- INTEGRATION
  - WHAT FIXTURES ARE REQUIRED TO BRING BOOSTER TO VERTICAL?
- TEST/CHECKOUT
  - WHAT INCREASE IN DATA HANDLING CAPABILITY BY THE F/R WILL BE REQUIRED?
- LAUNCH
  - WHAT IS CONFIGURATION OF LRB TANK VENTS?

LIQUID ROCKET BOOSTER (LRB) INTEGRATION STUDY

JAN. 20, 1988
K. HUMPHRIES

TYPICAL CHECKLIST ITEMS (CONT'D)

- RECOVERY
  - WHAT ADDITIONAL SHIP SIDE EQUIPMENT WILL BE REQUIRED (POWER, PURGE, ETC.) ?
- DISASSEMBLY SAFING
  - WHAT TYPE AND AMOUNT OF RESIDUALS NEED BE ADDRESSED AT GROUND RECOVERY AREA?
- REFURBISHMENT
  - WHAT WILL BE THE LEVEL OF REFURBISHMENT REQUIRED AT KSC?

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LIQUID ROCKET BOOSTER (LRB)
KSC IMPACT

JAN. 20, 1988

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LIQUID ROCKET BOOSTER (LRB) KSC IMPACT

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PROCESS OPERATION REQUIREMENTS

- INTRODUCTION
- LRB GROUND PROCESSING OVERVIEW
- TEST AND CHECKOUT OPERATIONS SUMMARY
- LRB VEHICLE DESIGN RECOMMENDATIONS FOR GROUND PROCESSING
- GROUND SYSTEMS DESIGN RECOMMENDATIONS FOR LRB
- ISSUES AND QUESTIONS

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LIQUID ROCKET BOOSTER (LRB) INTEGRATION STUDY

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INTRODUCTION

THIS PRESENTATION IS BASED ON THE CONCEPT OF PROCESSING A MAJOR LIQUID FUEL PROPULSION SYSTEM AS AN STS FLIGHT ELEMENT THROUGH KSC. IT IS CONSISTENT WITH EXISTING STS LAUNCH OPERATIONS CONCEPTS AND BASED ON THE LESSONS OVER THE LAST 25 YEARS.

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LIQUID ROCKET BOOSTER (LRB) INTEGRATION STUDY

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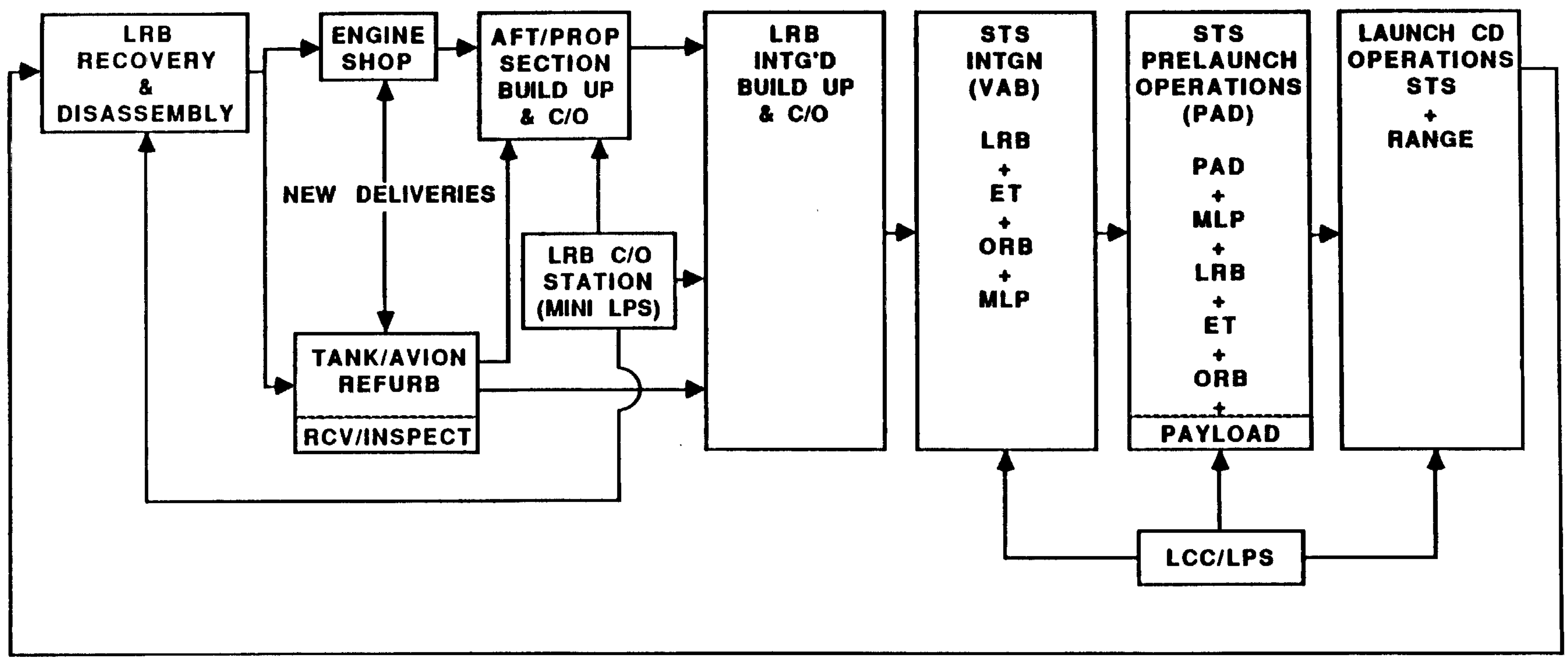

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TEST AND CHECKOUT OPERATIONS SUMMARY RECOMMENDATIONS

- ENGINE SHOP
  - RECEIVE/INSPECT NEW DELIVERY ENGINES
  - PERFORM STAND ALONE ENGINE REFURBISHMENT, MAINTENANCE AND CHECKOUT
- LRB ASSEMBLY FACILITY
  - RECEIVE/INSPECT NEW DELIVERY LRB FLIGHT HARDWARE
  - PERFORM LRB SYSTEMS REFURBISHMENT, MAINTENANCE AND INDIVIDUAL SYSTEMS CHECKOUT
  - PERFORM LRB AFT/PROPULSION SYSTEMS BUILDUP* AND TEST (ENGINE AND LRB PROPULSION SYSTEM INTEGRATION)
  - PERFORM LRB INTEGRATED SYSTEMS TEST*

*ASSUMES LRB IS TRANSPORTED TO VAB AS COMPLETE ELEMENT

TEST AND CHECKOUT OPERATIONS SUMMARY RECOMMENDATIONS

- LRB CHECKOUT STATION
  - "MINI" LPS SYSTEM TO SUPPORT ALL LRB POST-FLIGHT SAFING, TEST AND CHECKOUT OPERATIONS UP TO READY
  - FOR TRANSFER TO VAB.

- LRB RECOVERY FACILITY
  - INITIAL RECEIVING, INERT PROPELLANT SYSTEMS AND SAFE ORDNANCE.
  - POWER, DATA AND COMMAND CAPABILITY REQUIRED.
  - RECEIVE/INSPECT RETURN FROM FLIGHT HARDWARE AFTER INERT/SAFING

TEST AND CHECKOUT OPERATIONS SUMMARY RECOMMENDATIONS

- VAB (STS INTEGRATED) OPERATIONS
  - MATE LRB TO MLP
  - MATE ET TO LRBs
  - MATE ORBITER TO ET
  - PERFORM SHUTTLE INTEGRATED TEST TO VERIFY BASIC ORBITER/ET/LRB AND MLP AVIONICS/FLUIDS INTERFACES

- STS PRELAUNCH PAD OPERATIONS
  - PAD SHUTTLE INTERFACE TEST: VERIFY BASIC STS VEHICLE TO LAUNCH PAD FLUID, PROPELLANT AND AVIONICS INTERFACES.
  - SHUTTLE HYPERGOLIC PROPELLANT SERVICING: PERFORMS ORBITER OMS/RCS, APU PROPELLANT SERVICING AND LRB APU PROPELLANT SERVICING. (LRB HYPERGOL SERVICE)
  - TERMINAL COUNTDOWN DEMONSTRATION TEST: VERIFIES LAUNCH TEAM READINESS AND FLIGHT CREW TIMELINE. NO CRYOGENIC PROPELLANT LOAD OR APU ACTIVATION. AVIONICS ARE IN PRE-FLIGHT CONFIGURATION WITH GROUND LAUNCH SEQUENCER UNTIL CUTOFF DECLARED AT APPROXIMATELY T-5 SECONDS.
  - FINAL SHUTTLE ORDNANCE CONNECTION: PERFORMS ALL FINAL RANGE SAFETY, HOLDDOWN POST AND PAYLOAD ORDNANCE PRE-LAUNCH CONNECTIONS. ORBITER AND LRB AFT SECTIONS CLOSE-OUT FOR FLIGHT.

TEST AND CHECKOUT OPERATIONS SUMMARY RECOMMENDATIONS

- LAUNCH COUNTDOWN OPERATIONS
  - ORBITER/ET/LRB AVIONICS PREFLIGHT SYSTEMS ACTIVATION
  - ENGINE PREFLIGHT SYSTEMS ACTIVATION, SOFTWARE LOAD AND VERIFICATION
  - FINAL ORBITER CREW MODULE PREFLIGHT CONFIGURATION
  - ORBITER PRSD CRYOGENIC PROPELLANT SERVICING
  - ROTATING SERVICE STRUCTURE RETRACT
  - ET/LRB PROPELLANT SERVICE (IF LRB CRYOGENIC PROPELLANTS)
  - TERMINAL COUNTDOWN/LAUNCH

LIQUID ROCKET BOOSTER (LRB) INTEGRATION STUDY

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GROUND SYSTEMS DESIGN

RECOMMENDATIONS FOR LRB

- MAJOR NEW PROPELLANT LOADING SYSTEM REQUIRED AT PAD TO BE APPROXIMATELY SAME ORDER OF MAGNITUDE COMPLEXITY (OPERATIONALLY) REGARDLESS OF TYPE FUEL/OXIDIZER USED.
- LIFT OFF UMBILICALS TO PROVIDE GROUND POWER, COMMANDS AND DATA FOR PRELAUNCH MONITOR AND TEST.
- LRB RECOVERY AND TEAR DOWN FACILITY WILL REQUIRE SIGNIFICANT GSE TO SUPPORT COMMAND/DATA/POWER FOR INERT PURGING AND SAFING.
- LRB CHECKOUT STATION (MINI-CCMS/LPS) TO SUPPORT ALL LRB RECOVERY, BUILDUP AND PRE-VAB (MATE) TEST ACTIVITIES.
- LCC/LPS BE EXPANDED TO INCORPORATE NEW FIRINGROOM CONSOLES AND ASSOCIATED HARDWARE/ SOFTWARE TO ACCOMMODATE LRB AND LRB CX39 SUPPORT EQUIPMENT.

LRB VEHICLE DESIGN RECOMMENTATIONS FOR GROUND PROCESSING

- LRB SYSTEMS DESIGN SHOULD BE AS INDEPENDENT AS POSSIBLE FROM ORBITER AVIONICS.
  - SELF-CONTAINED POWER AND DATA TELEMETRY SYSTEMS
  - INDEPENDENT LRB INSTRUMENTATION HARDLINE VIA UMBILICAL
  - INDEPENDENT GROUND ELEC POWER VIA UMBILICAL
  - ORBITER AVIONICS I/F ONLY FOR GNC, SAFETY/FLIGHT CRITICAL COMMANDS AND DATA
- PROVIDE FOR STAND ALONE LRB INTEGRATED TEST.

LIQUID ROCKET BOOSTER (LRB) INTEGRATION STUDY

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ISSUES AND QUESTIONS

- INTEGRATION
  - ORBITER AVIONICS SYSTEMS CAPABILITY FOR EXPANSION LIMITED WITHOUT MAJOR REDESIGN/MOD EFFORT.

- LAUNCH
  - PROPELLANT SUPPLY CAPABILITIES (VENDOR).
  - IF HYPERGOLIC BOOSTER, WHAT SAFETY CONSTRAINTS WILL THERE BE ON PAYLOAD INTEGRATION AND OTHER ORBITER/ET PAD WORK?
  - WHAT ARE PLANS FOR PROPELLANT SERVICING UMBILICALS?
  - DRAMATIC INCREASE IN LAUNCH SYSTEMS COMPLEXITY.
  - SAFETY ISSUES IN LAUNCH PAD POST-ENGINE START SHUTDOWNS.
  - HOW TO MAINTAIN SAME CONFIDENCE/RELIABILITY FOR SUCCESSFUL ENGINE START/LIFTOFF WITH 11 LIQUID ENGINES VERSUS 3 LIQUID ENGINES AND 2 SRBs.

- RECOVERY
  - IF SEA LANDING, HOW TO INSURE LRB SAFE TO HANDLE/TOW? (IN-FLIGHT INERT CAPABILITY?)

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LIQUID ROCKET BOOSTER (LRB)
KSC IMPACT

JAN. 20, 1988

AGENDA

• INTRODUCTION	GORDON ARTLEY
• BASELINE	L. PAT SCOTT
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• SUMMARY	GORDON ARTLEY

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LIQUID ROCKET BOOSTER (LRB)

GROUND FACILITIES & SYSTEM IMPACTS

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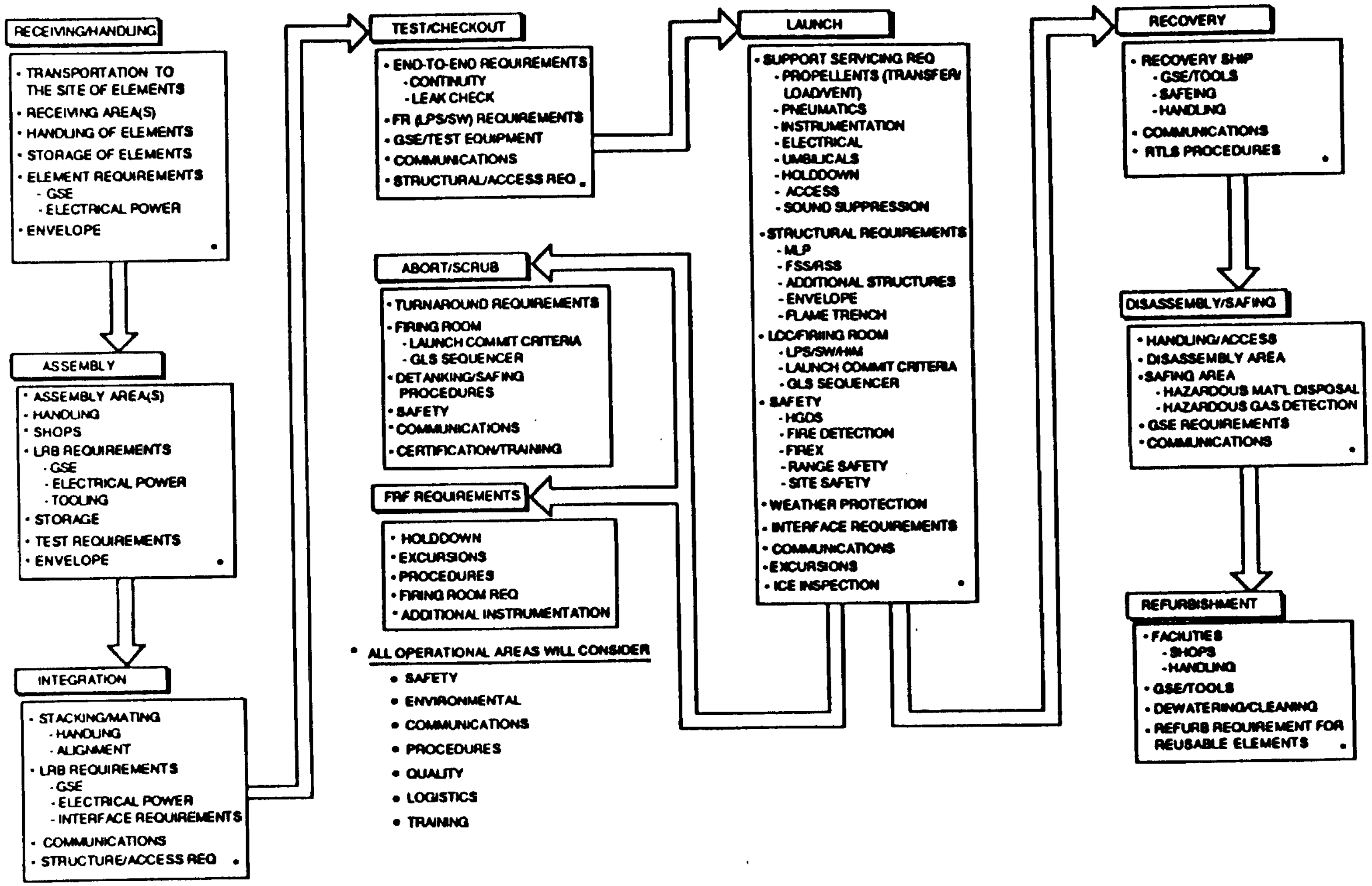

• ALL OPERATIONAL AREAS WILL CONSIDER
  • SAFETY
  • ENVIRONMENTAL
  • COMMUNICATIONS
  • PROCEDURES
  • QUALITY
  • LOGISTICS
  • TRAINING

LRB CONFIGURATION EVALUATION AREAS OF IMPACT

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LRB MODEL AND ASSUMPTIONS

LRB MODLE

- LOX/RP1 (PRESSURE FEED)
- 175' LONG X 14.2' DIAMETER
- TANK ASSEMBLY, AVIONICS PACKAGE, ENGINES RECEIVED AT KSC SEPARATELY
- ALL LRB SERVICES PROVIDED IN AFT
- THREE ACCESS PLATFORM AREAS (NOSE, MID-BODY, AFT) AND ENGINE ACCESS NEEDED FOR THE LRB WHEN IN THE VERTICAL POSITION
- LRBs ASSEMBLED AND TESTED - HORIZONTALLY
- RECOVERY OF AVIONICS AND EGINES (TANKS EXPENDABLE)
- REFURBISHMENT BY ELEMENT CONTRACTOR

ASSUMPTIONS

- TRANSITION TIME FRAME - 1994 THROUGH 1998
- LAUNCH RATE DURING TRANSITION - 14 PER YEAR
- AT THIS TIME GROUND RULE OUT IMPLEMENTATION OF ASRM OR SHUTTLE DERIVITIVES
- DURING TRANSITION DUAL LAUNCH CAPABILITY OF SRB AND LRB CONFIGURED STS

LRB RECEIVING/STORAGE

DRIVERS

- INADEQUATE FLOOR SPACE IN VAB HIGH BAYS 2 AND 4 AND LOW BAY FOR HORIZONTAL PROCESSING
- ET PROCESSING OF 12 TO 14 FLIGHTS PER YEAR
- SRB STACKING IN HIGH BAYS 1 AND 3 REQUIRES CLEARING HIGH BAYS 2 AND 4

IMPACTS

- SITE LOCATION (APPROXIMATELY 10 ACRES)
- NEW RECEIVING AND STORAGE BUILDING REQUIRED (3 HORIZONTAL STORAGE CELLS APPROXIMATELY 75,000 SQ. FT.)
- BONDED STORAGE AREA FOR FLIGHT ELEMENTS

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VEHICLE ASSEMBLY BUILDING FLOOR PLAN

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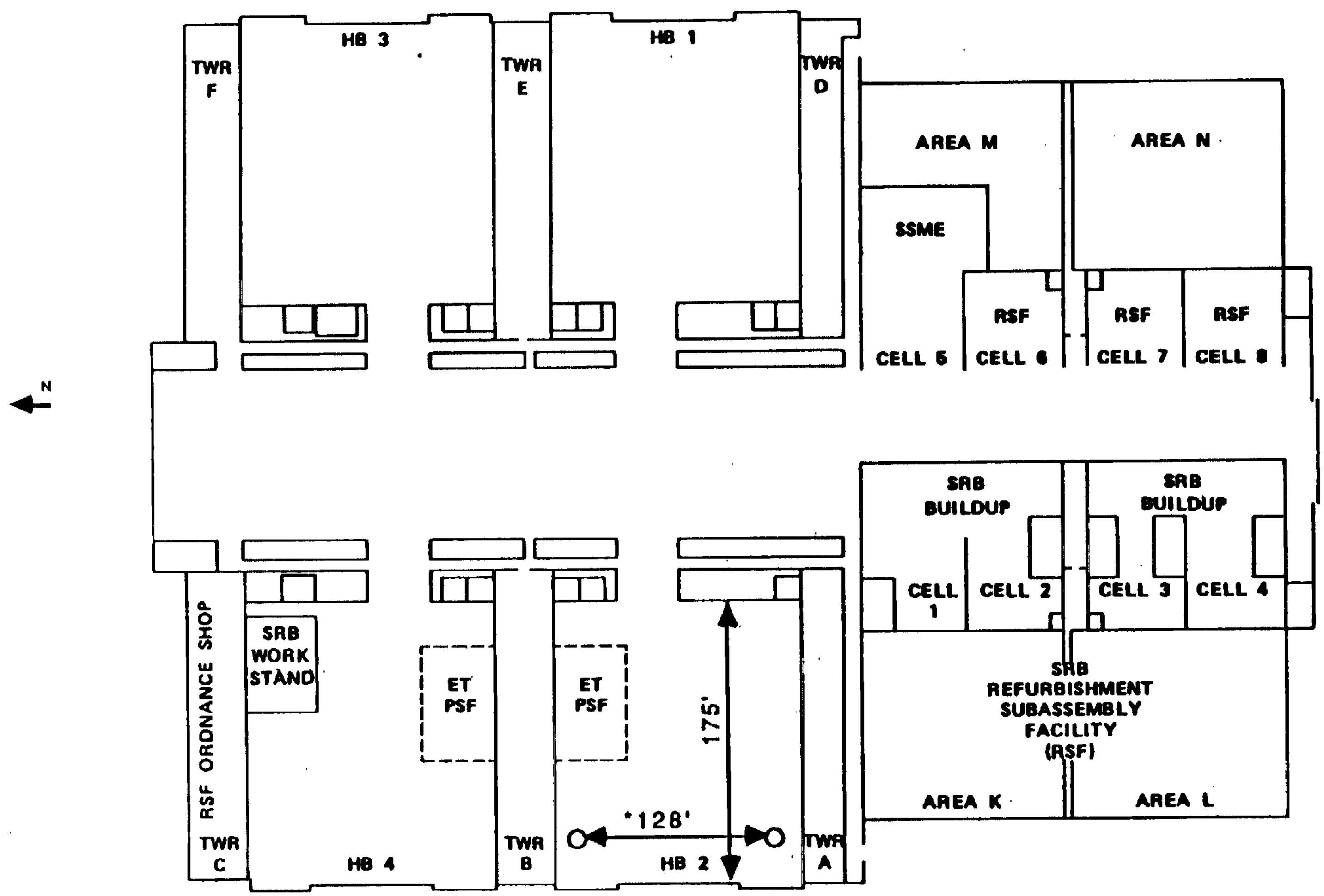

* BETWEEN MLP POSTS

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LRB PROCESSING (ASSEMBLY/CHECK-OUT)

DRIVERS

- INADEQUATE FLOOR SPACE IN VAB HIGH BAYS 2 AND 4 FOR HORIZONTAL PROCESSING
- ET PROCESSING OF 12 TO 14 FLIGHTS PER YEAR
- SRB STACKING IN HIGH BAYS 1 AND 3 REQUIRES CLEARING HIGH BAYS 2 AND 4

LRB PROCESSING (ASSEMBLY/CHECK-OUT)

IMPACTS

- o SITE LOCATION (APPROXIMATELY 10 ACRES)
- o NEW ASSEMBLY AND CHECK-OUT FACILITY
  - EACH STORAGE CELL EQUIPPED FOR HORIZONTAL ASSEMBLY AND CHECK-OUT
  - ENGINE INSTALLATION AND CHECK-OUT
  - OFFICE/PERSONNEL SUPPORT SPACE
  - AVIONICS SHOP 10,000 SQ. FT. (APPROXIMATELY)
  - ENGINE SHOP 20,000 SQ. FT. (APPROXIMATELY)
  - MACHINE SHOP
  - ELECTRONICS SHOP
- o INDEPENDENT MINI-LPS (CONTROL ROOM AND SOFTWARE)

LRB STORAGE AND PROCESSING

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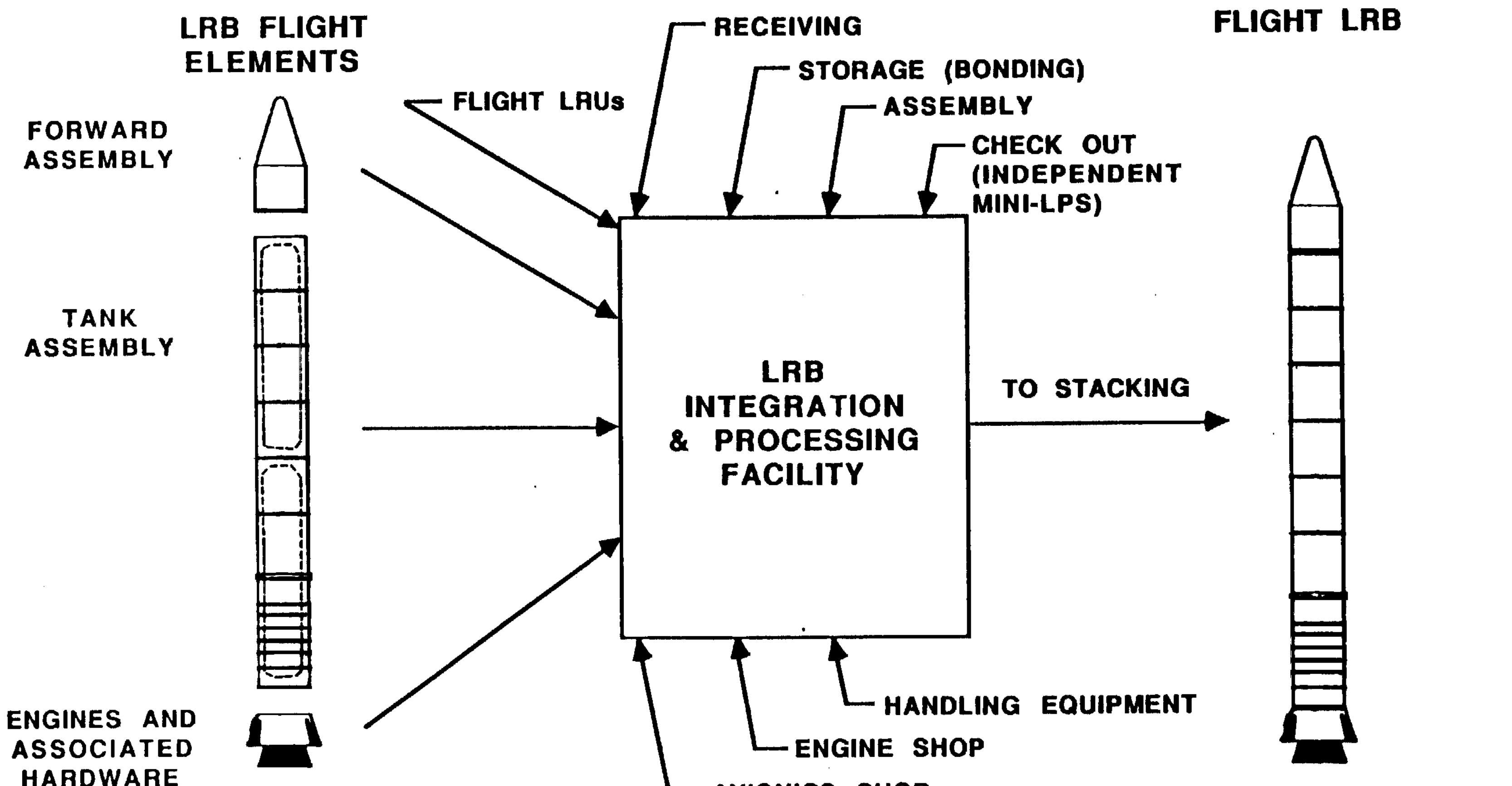

ALL ELEMENTS RECEIVED ON TRANSPORT DOLLIES WITH HANDLING EQUIPMENT

FLIGHT LRB TRANSFERRED TO STACKING ON TANK ASSEMBLY TRANSPORTER

LRB RECEIVING/STORAGE/PROCESSING

ISSUES

o ELEMENTS HANDLING

- MODS TO BARGE FOR TIE DOWNS
- TRANSPORTER MUST MATE TO KSC ET TOWING VEHICLE
- HANDLING FIXTURES FOR AVIONICS/ENGINES
- STRONG BACK/SLINGS
- VERTICAL LIFT PLATFORM FOR ENGINE/AVIONICS INSTALLATION

STACKING/VEHICLE INTEGRATION

DRIVER

- INCOMPATIBLE STACKING/VEHICLE INTEGRATION OPERATION IN HIGH BAYS 1 AND 3 FOR LRB AND SRB
- LAUNCH SCHEDULE AND PROCESSING REQUIREMENTS OF SRB AND LRB CONFIGURED STS
- LRB HIGH BAYS 1 AND 3 MODIFICATION IMPLEMENTATION SCHEDULE

IMPACT

- REQUIRES A FOURTH MLP FOR LRB - 1994
- MODIFIED MLP FOR LRB - 1995
- REQUIRES A NEW BOOSTER STACKING FACILITY - 1993
- IMPLEMENTATION OF MODIFICATION SCHEDULE VS. PROCESSING SCHEDULE
- VAB PLATFORM MODIFICATIONS FOR LRB - ADD EXTENDABLES FOR SRB

LRB TRANSITION PLAN

	1993	1994	1995	1996	1997	1998
LRB FLIGHTS	0	3	6	9	12	14
SRB FLIGHTS	13	10	8	5	2	0
TOTAL	13	13	14	14	14	14
MLPs REQUIRED						
FOR LRB	0	1	2	2	2	3
FOR SRB	3	3	2	2	1	0
STACKING FACILITIES						
FOR LRB	0	1	1	2	2	3
FOR SRB	2	2	2	1	1	0

LRB INTEGRATION

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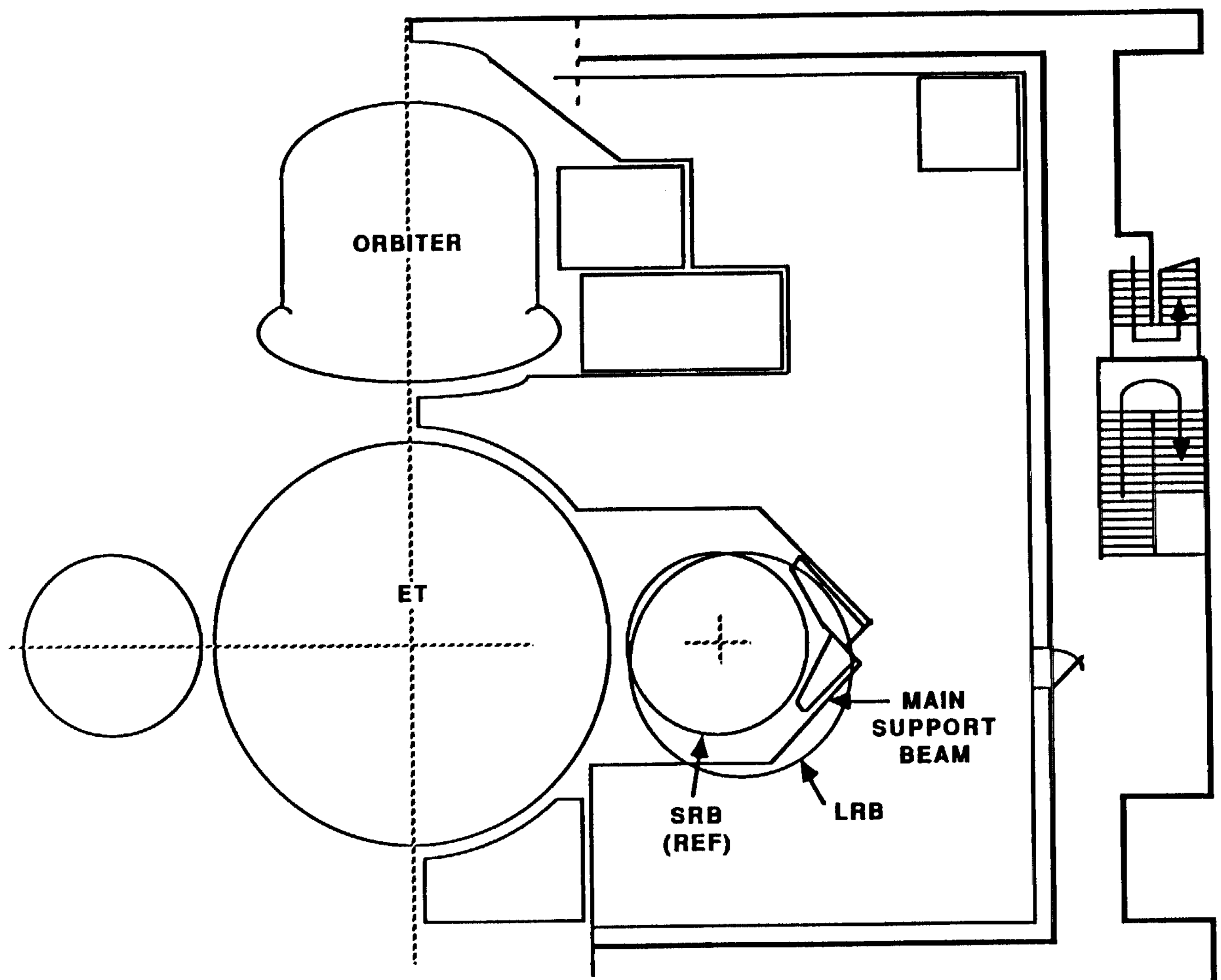

VAB PLATFORM

STACKING/VEHICLE INTEGRATION

ISSUES

- o LRB STIFFNESS
- o LRB HANDLING/LIFTING EQUIPMENT DESIGN AND PRODUCTION

STACKING/VEHICLE INTEGRATION/LAUNCH

MLP

DRIVER

- o WEIGHT LIMITATION OF EXISTING MLP
- o MEETING LAUNCH SCHEDULE OF LRB AND SRB CONFIGURATIONS REQUIRES A FOURTH MLP
- o COMMON MLP CANNOT SUPPORT BOTH LRB AND SRB
  - LRB CONFIGURATION AND CONNECTION POINTS
  - VEHICLE ENGINE FIRING SEQUENCES
  - LRB ENGINE SERVICING REQUIREMENTS

STACKING/VEHICLE INTEGRATION LAUNCH

MLP

- NEW HOLD-DOWN POSTS
- NEW HAUNCH
- NEW LRB ENGINE SERVICE PLATFORM
- NEW HIMS AND CABLE FOR LPS
- NEW LRB SERVICE UMBILICALS
- PIC SYSTEM
- ENLARGE BOOSTER FLAME HOLE (PRESSURE FEED)

STACKING/VEHICLE INTEGRATION/LAUNCH

MLP

ISSUES

- o GOX VENT CAPABILITY
- o LOX LOADING/REVERT/DRAIN CAPABILITY
- o RP1 LOADING/DRAIN CAPABILITY

NEW STACKING FACILITY

DRIVER

- INCOMPATIBLE INTEGRATION STACKING OPERATIONS IN HIGH BAYS 1 AND 3 FOR LRB AND SRB
- INCOMPATABLE LAUNCH SCHEDULE AND PROCESSING REQUIREMENTS OF SRB AND LRB CONFIGURED STS
- LRB HIGH BAYS 1 AND 3 MODIFICATION IMPLEMENTATION SCHEDULE

NEW STACKING FACILITY

IMPACTS

- o NEW FACILITY WITH ACCESS FOR PROCESSING
- o MLP/CRAWLER SCHEDULE
- o STAGING AREA - PREPARATION WORK
- o SITE LOCATION

LAUNCH PAD

- DRIVERS
  - MEETING LAUNCH SCHEDULES USING TWO PADS FOR BOTH LRB AND SRB
  - LRB PAD MODIFICATION IMPLEMENTATION SCHEDULE
  - ENGINE FIRING SEQUENCES AND DURATIONS PRIOR TO LIFTOFF
  - LRB GOX VENT CONFIGURATION
  - SCRUB/TURNAROUND
  - FRF

LAUNCH PAD

- IMPACTS
  - NEW RP1 FACILITY AND SYSTEM
  - NEW LOADING SYSTEM FOR LOX (CAPACITY)
  - NEW UMBILICALS (LOADING, GOX VENT, ELECTRICAL)
  - RELOCATION/MODS OF EXISTING UMBILICALS (HYDROGEN VENT GOX ARM, TSM)
  - NEW GOX VENT UMBILICAL SYSTEM
  - NEW OR MODIFICATION OF EXISTING ACCESS PLATFORM
  - NEW FLAME DEFLECTORS/PROTECTION SYSTEM
  - ICE SUPPRESSION
  - LPS-GLS AND OTHER CCMS SOFTWARE

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MLP & NEW UMBILICAL TOWER OPTION

JAN. 20, 1988
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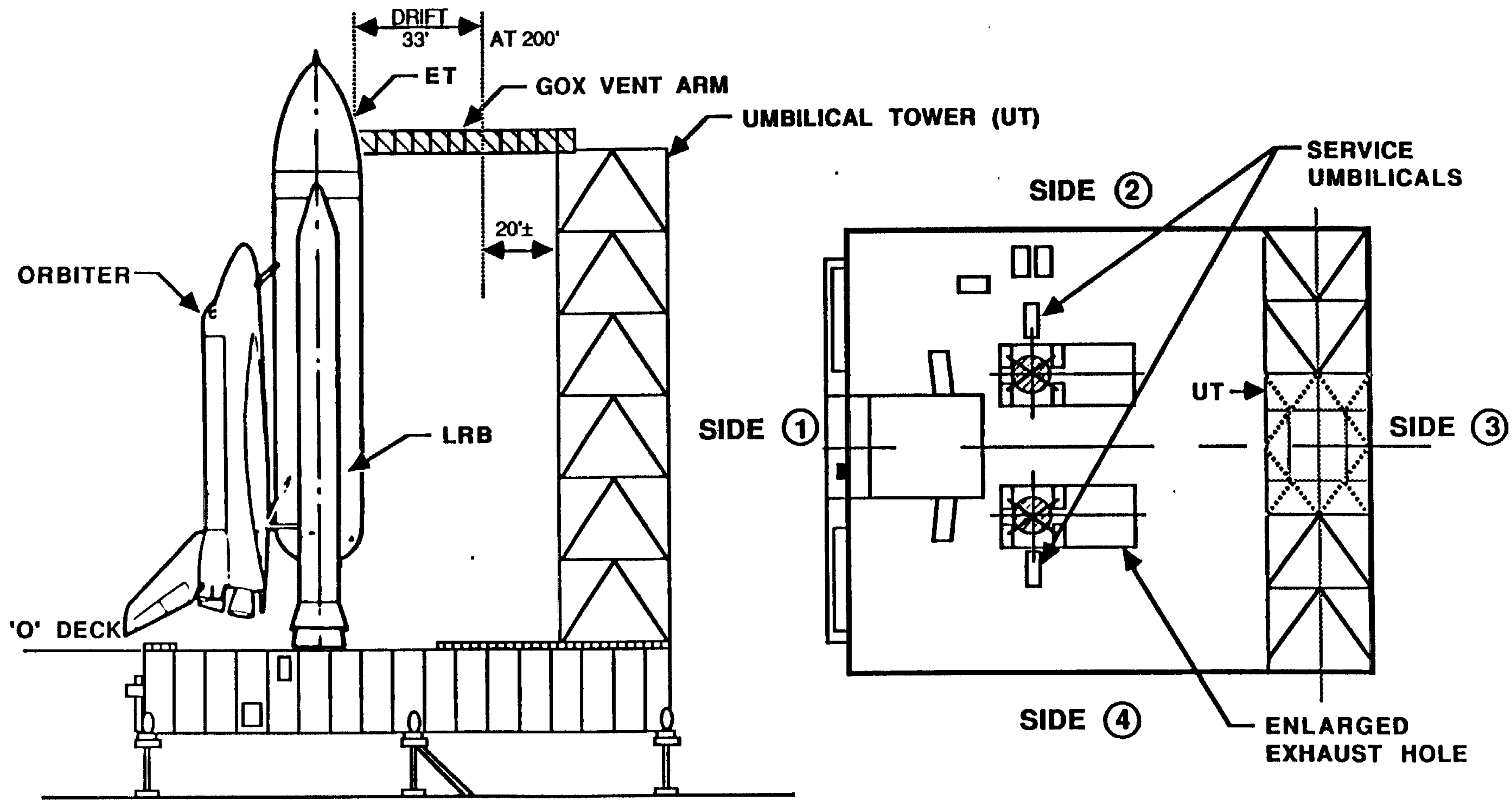

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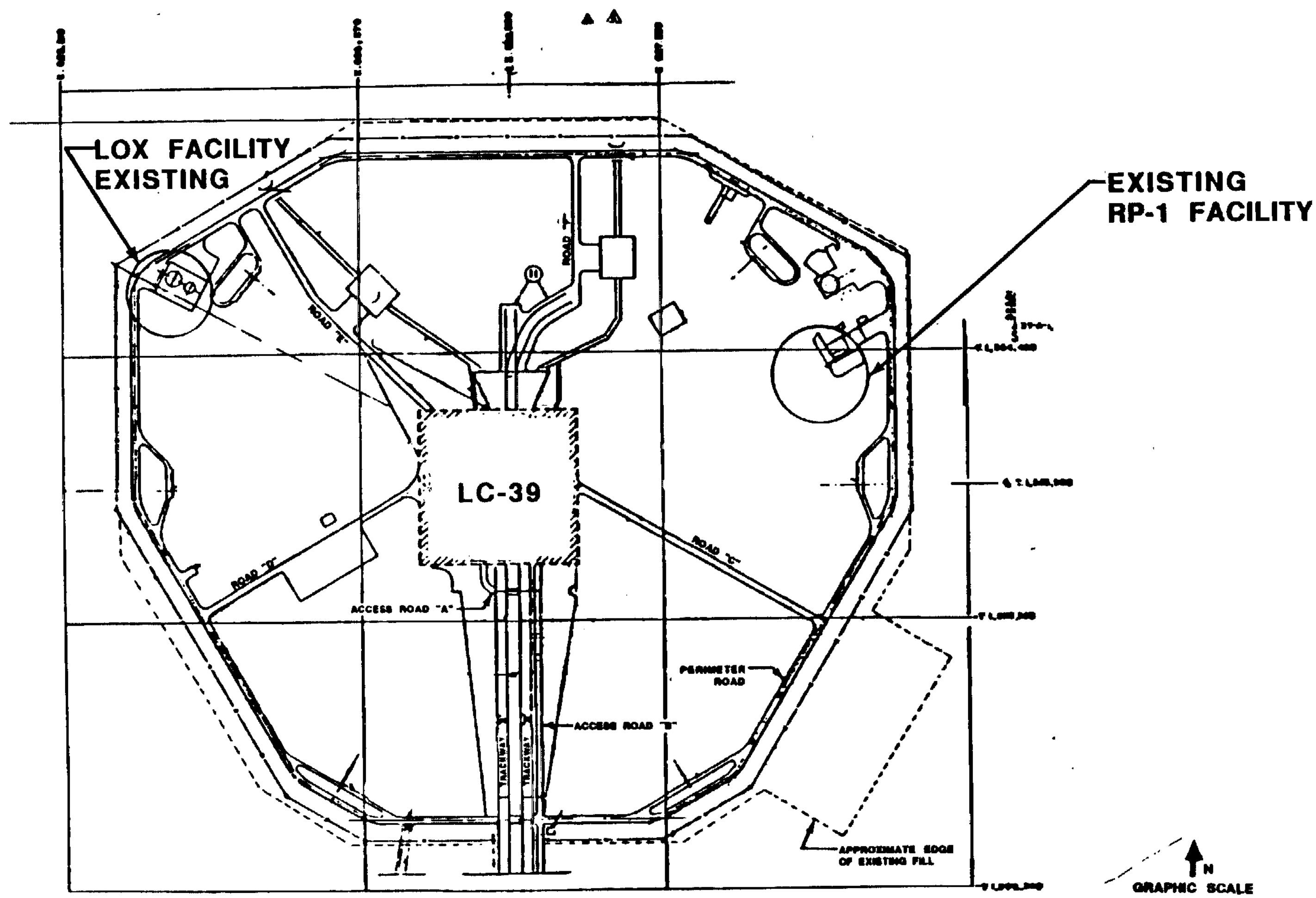
LAUNCH PAD

ISSUES

- DRIFT CURVES AND LAUNCH OVER-PRESSURES
- SOUND SUPPRESSION SYSTEM REQUIREMENTS
- FIREX SYSTEM SUPPORT REQUIREMENTS FOR ENGINE SHUT-DOWN/NO LIFT-OFF

LIQUID ROCKET BOOSTER (LRB) INTEGRATION STUDY

JAN. 20, 1988
G. DEBLASIO



GENERAL PLAN - LC39 PAD

LRB RECOVERY

DRIVER

- RETRIEVAL OF FLIGHT ELEMENTS FROM OCEAN

IMPACTS

- NEW BARGE WITH CRANE AND TUGS
- ENVIRONMENTAL/SAFETY REQUIREMENTS IF HYPERGOL POWERED TVC UNIT USED
- NEW SLIP/DOCKING FACILITIES FOR UNLOADING
- GROUND TRANSPORT AND HANDLING FOR RECOVERED ELEMENTS

LRB DISASSEMBLY/SAFING

DRIVER

- o DISASSEMBLY OF FLIGHT ELEMENTS

IMPACTS

- o HAZARDOUS MATERIAL AND PYROTECHNIC DISPOSAL
- o LOCATION
- o NEW HANDLING EQUIPMENT REQUIREMENTS
- o NEW DEWATERING EQUIPMENT

LRB REFURBISHMENT

DRIVER

- o REFURBISHMENT AT ELEMENT CONTRACTOR LOCATION

IMPACT

- o TRANSPORT OF ELEMENTS

LRB ELEMENT DESIGN CONSIDERATION

RECEIVING/STORAGE/ASSEMBLY/CHECK-OUT

- ASSEMBLED AND PROCESSED HORIZONTALLY
- TRANSPORTERS AND DOLLIES CAPABLE OF SUPPORTING STORAGE AND PROCESSING (ASSEMBLY AND CHECK-OUT)

STACKING

- LRB ASSEMBLY STRONG ENOUGH TO BE ROTATED AND LIFTED ONTO THE MLP

LAUNCH AREA (PAD/MLP)

- DO NOT VENT CRYOGENICS AT THE NOSE TO AVOID A VENT ARM
- FILL/DRAIN/VENT CAPABILITIES/REQUIREMENTS AT THE AFT
- VERTICAL ENGINE CHANGE-OUT CAPABILITY

RECOVERY

- DO NOT USE HYPERGOL POWERED TVC UNITS

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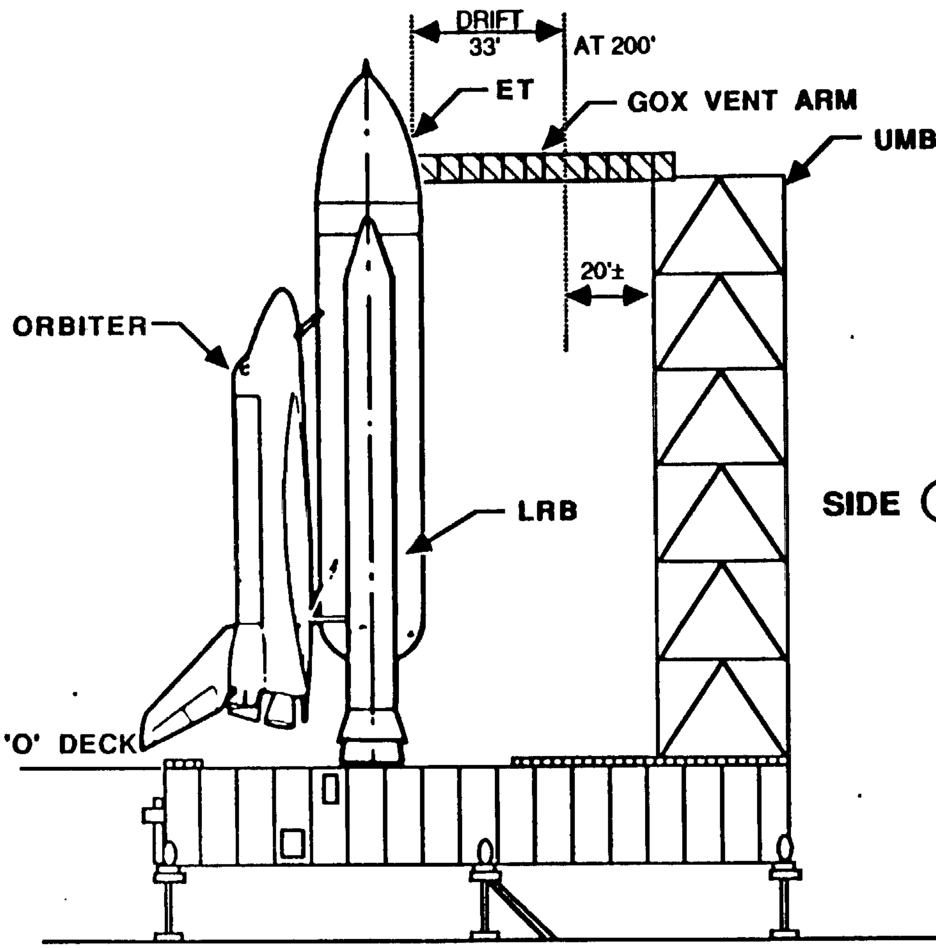
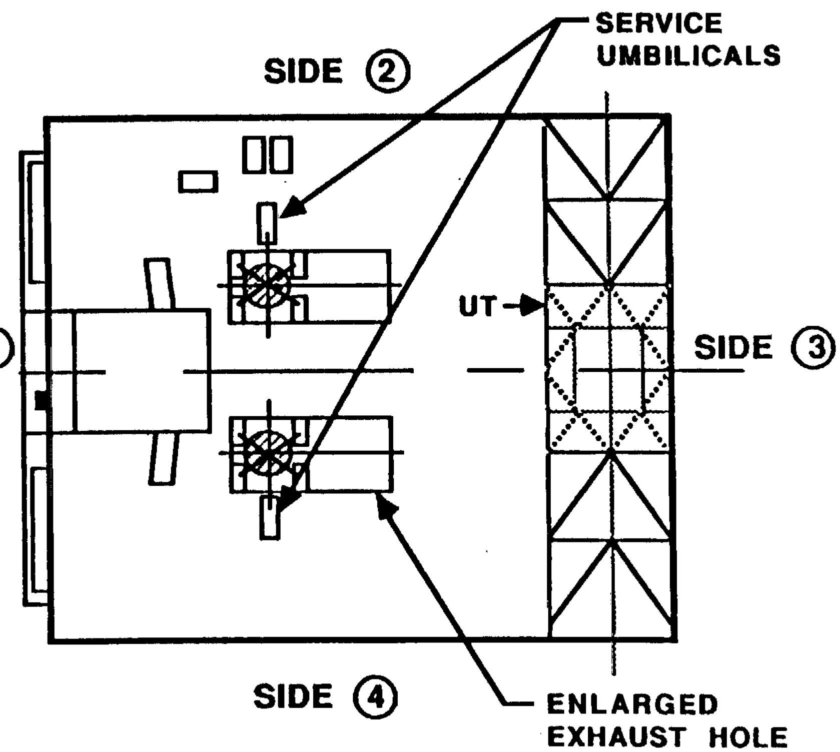
MLP & NEW UMBILICAL TOWER OPTION

JAN. 20, 1988
G. DEBLASIO





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LIQUID ROCKET BOOSTER (LRB) GROUND FACILITIES & SYSTEM IMPACTS

JAN. 20, 1988
G. DEBLASIO

NEAR TERM STUDIES

- CONCEPT FOR INTERGRATED LRB PROCESSING FACILITY
- ADDRESS THE MLP AND VAB STACKING NEEDS MODIFICATIONS AND NEW CONSTRUCTION REQUIREMENTS
- PARALLEL LPS FOR LRB. (INCLUDING H/W SAFING)
- LPS IMPACTS OF PUMP FEED
- DELTA IMPACTS FOR LOX/LH2 (PRESSURE & PUMP FEED)
- DELTA IMPACTS FOR HYPERGOL (PRESSURE & PUMP FEED)

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LIQUID ROCKET BOOSTER (LRB) KSC IMPACT

JAN. 20, 1988

AGENDA

• INTRODUCTION	GORDON ARTLEY
• BASELINE	L. PAT SCOTT
• REQUIREMENTS	R. KEITH HUMPHRYES / STEVE BLACK
• IMPACTS	GREGORY DEBLASIO / ROGER LEE
• SUMMARY	GORDON ARTLEY

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ENVIRONMENTAL/SAFETY IMPACTS

N_2O_4/MMH PROPELLANTS

ENVIRONMENTAL IMPACTS

- o Air Quality
  - Capacity of current emission controls (scrubbers) to meet LRB requirements
  - Ignition by-products
  - Ozone depletion concerns
- o Water Quality
  - Minimal impact in immediate vicinity of the launch pads other than non-contained spills or non-detected leaks
  - Possible impact to marine life if residuals escape from LRBs in the recovery area

ENVIRONMENTAL IMPACTS CONT'D

- o Hazardous Waste
  - Increase in quantity of hypergols used will likely result in increase of hazardous waste generated
  - Disposal of hypergol waste presents unique problems
  - Capacity of current disposal methods (fire training on site and incineration off site) may not be adequate if large quantities are generated
- o Other Environmental Impacts
  - Increased production will impact environmental requirements at the manufacturing sites

ENVIRONMENTAL IMPACTS CONT'D

- New concept will require Environmental Impact Statement with extensive development effort

o Other Environmental Concerns

  - Propellant or LRB delivery by barge creates concern that increased barge traffic may affect endangered species

SAFETY IMPACTS

- o Personnel Protection
  - Increased use of hypergols increases the risk of personnel exposure to toxic chemicals
  - Scape suit requirements will increase substantially
  - Current clear zone for hypergol operations in the pad areas may require expanding
  - Possible exposure of personnel to hypergols during recovery and disassembly
  - Large spills or catastrophic explosions could expose large numbers of people to toxic vapors
  - Current vapor detection and monitoring system will require expansion

SAFETY IMPACTS CONT'D

- o Fire Detection/Protection
  - Current Fire Detection/Protection system at the pads not adequate for LRB requirements
- o Transportation
  - Transporting projected quantities of hypergols from manufacturing sites over public highways and through populated areas significantly increases the risk of exposing the public to toxic chemicals

OTHER CONCERNS

- Current trend is toward more stringent regulatory requirements

- Community Right-To-Know Law

CONCLUSION

- The projected use of huge quantities of MMH and N_2O_4 as primary propellants for the LRB raise serious environmental and safety concerns, which make them highly questionable from an environmental and safety standpoint

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LIQUID ROCKET BOOSTER (LRB) KSC IMPACT

JAN. 20, 1988

AGENDA

- INTRODUCTION — GORDON ARTLEY
- BASELINE — L. PAT SCOTT
- REQUIREMENTS — R. KEITH HUMPHRYES / STEVE BLACK
- IMPACTS — GREGORY DEBLASIO / ROGER LEE
- SUMMARY — GORDON ARTLEY

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LIQUID ROCKET BOOSTER (LRB) INTEGRATION STUDY

JAN. 20, 1988
G. ARTLEY

IMPACT SUMMARY

- NEW SRB STACKING FACILITY OR ADDITIONAL VAB HIGH BAY
- FOURTH MLP REQUIRED
- NEW INTEGRATED LRB PROCESSING FACILITY/PROCEDURES/GSE/ STANDALONE LPS TO SUPPORT
- NEW FLAME DEFLECTOR REQUIRED
- NEW LPS, PMS AND COMMUNICATION SYSTEMS REQUIRED
- VAB PLATFORM AND MLP MODS WILL INTERRUPT PROCESSING/LAUNCH RATE
- NEW ACCESS TOWERS REQUIRED ON PAD OR MLP
- OVER-WEIGHT RSS LIMITS NEW ACCESS MODS
- NEW CONSOLES, FIRING ROOM/RECERTIFICATION

LIQUID ROCKET BOOSTER (LRB) INTEGRATION STUDY

JAN. 20, 1988
G. ARTLEY

ISSUE - SUMMARY

- COMPLEXITY OF TERMINAL COUNTDOWN - 7 OR 11 LIQUID ENGINES VERSUS 3 SSME AND 2 SRB ENGINES
- PROPELLANT HANDLING/STORAGE/ENVIRONMENTAL
- SCENARIO FOR RECOVERY, DISASSEMBLY AND REFURBISHMENT
- ENGINE ACCESS AND REMOVAL AT THE PAD
- ENGINE SEQUENCE AND TIMING BEFORE LIFTOFF
- WATER REQUIREMENTS - DEFLECTOR/FIREX/SOUND SUPPRESSION
- LAUNCH DRIFT CURVES VERSUS NEW UMBILICALS/STRUCTURES
- EXPANSION OF FIRING ROOMS/LPS CAPABILITIES
- TWANG EFFECTS VERSUS TSM AND NEW UMBILICALS
- PRE-MATE LPS PROCESSING IN HORIZONTAL MODE

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LIQUID ROCKET BOOSTER (LRB) INTEGRATION STUDY

JAN. 20, 1988
G. ARTLEY

NEAR TERM STUDY TASKS

- SUPPORT NASA DOWN SELECTION
- PRELIMINARY OPERATIONAL SCENARIOS
- MODIFICATION SCHEDULE OPTIONS: VAB - MLP - PAD
- SYSTEM LEVEL IMPACT ANALYSIS AND ASSESSMENTS
- MITIGATE HYPERGOL SCENARIO OPTIONS

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VOLUME IV

SECTION 3

INTEGRATED WORKING GROUP

April 21, 1988

81005-01BM24c

KSC OPS ASSESSMENTS

APRIL 21, 1988
L. SCOTT/G. ARTLEY

OUTLINE

- TRANSITION PLANNING ISSUES
- APPROACH TO LRB PROCESSING
- GENERIC LRB FLOW
- KSC FACILITY ACTIVATION SCHEDULE
- DETAILED KSC FACILITY REQUIREMENTS
  - HORIZONTAL PROCESS FACILITY
  - VAB
  - MLP
  - PAD
  - LCC
- LRB LAUNCH RATE BUILD-UP REQUIREMENTS

TRANSITION PLANNING ISSUES

APRIL 21, 1988
L. SCOTT/G. ARTLEY

- FACILITY ACTIVATION SCHEDULE
  - LRB FIRST FLOW REQUIREMENTS
- MIXED FLEET OPERATIONS
- TRANSITION AND LRB BUILD-UP RATE
- INTEGRATION WITH OTHER PROGRAMS (STS-C, SPACE STATION, ASRM, ETC.)

APPROACH TO LRB PROCESSING

APRIL 21, 1988
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- NEW LRB HORIZONTAL PROCESS FACILITY
- NEW MLP DESIGNED / BUILT FOR LRB
- PAD MODS FOR LOX / RP-1 PROPELLANTS
- VAB MODS FOR LRB (PLATFORMS, ETC)
- NEW / MOD GROUND SOFTWARE FOR LRB
- NEW / MOD GROUND SUPPORT EQUIPMENT
- ADDITIONAL FACILITIES TO SUPPORT LRB LAUNCH RATE BUILD-UP

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GENERIC LRB PROCESS FLOW

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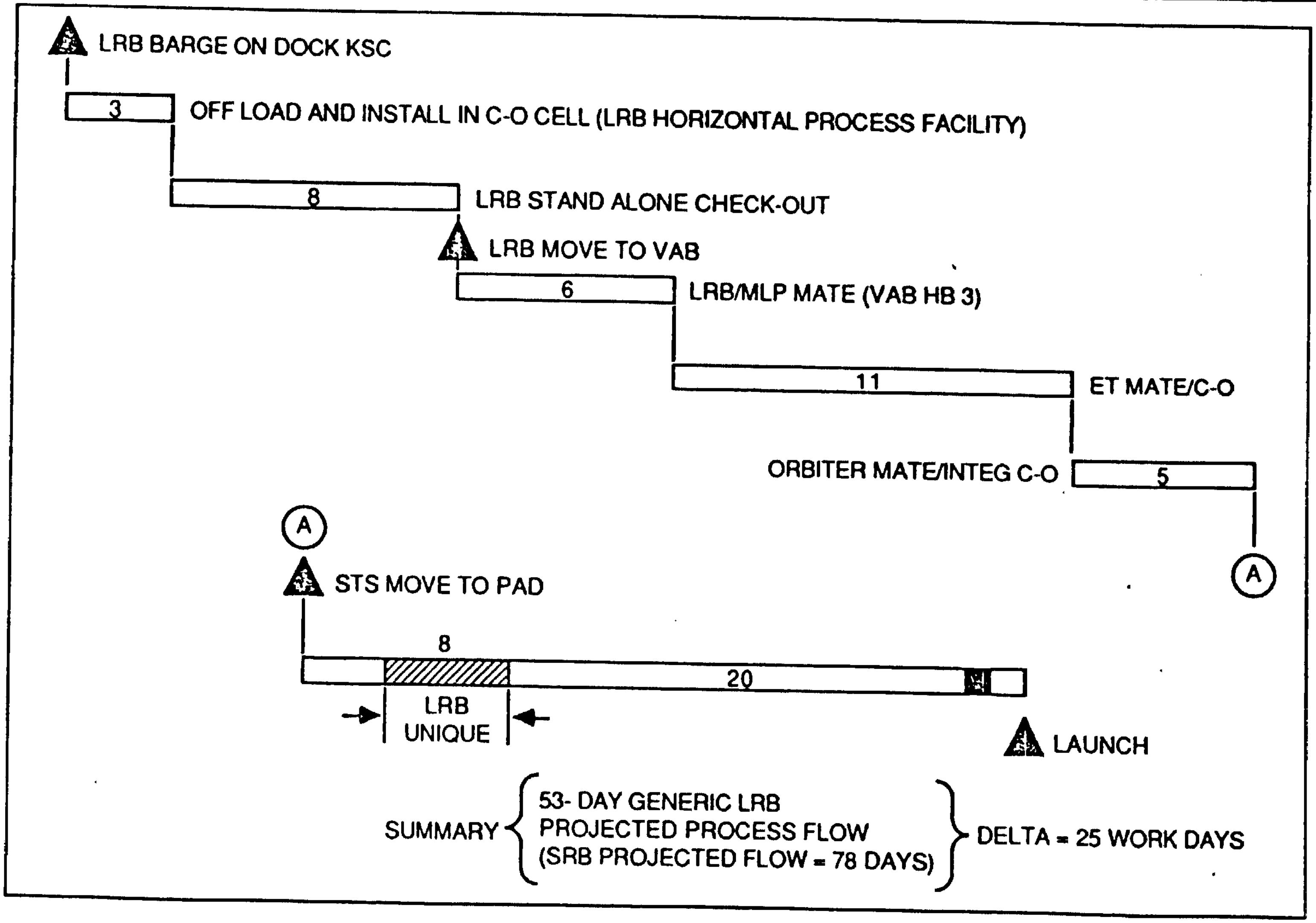

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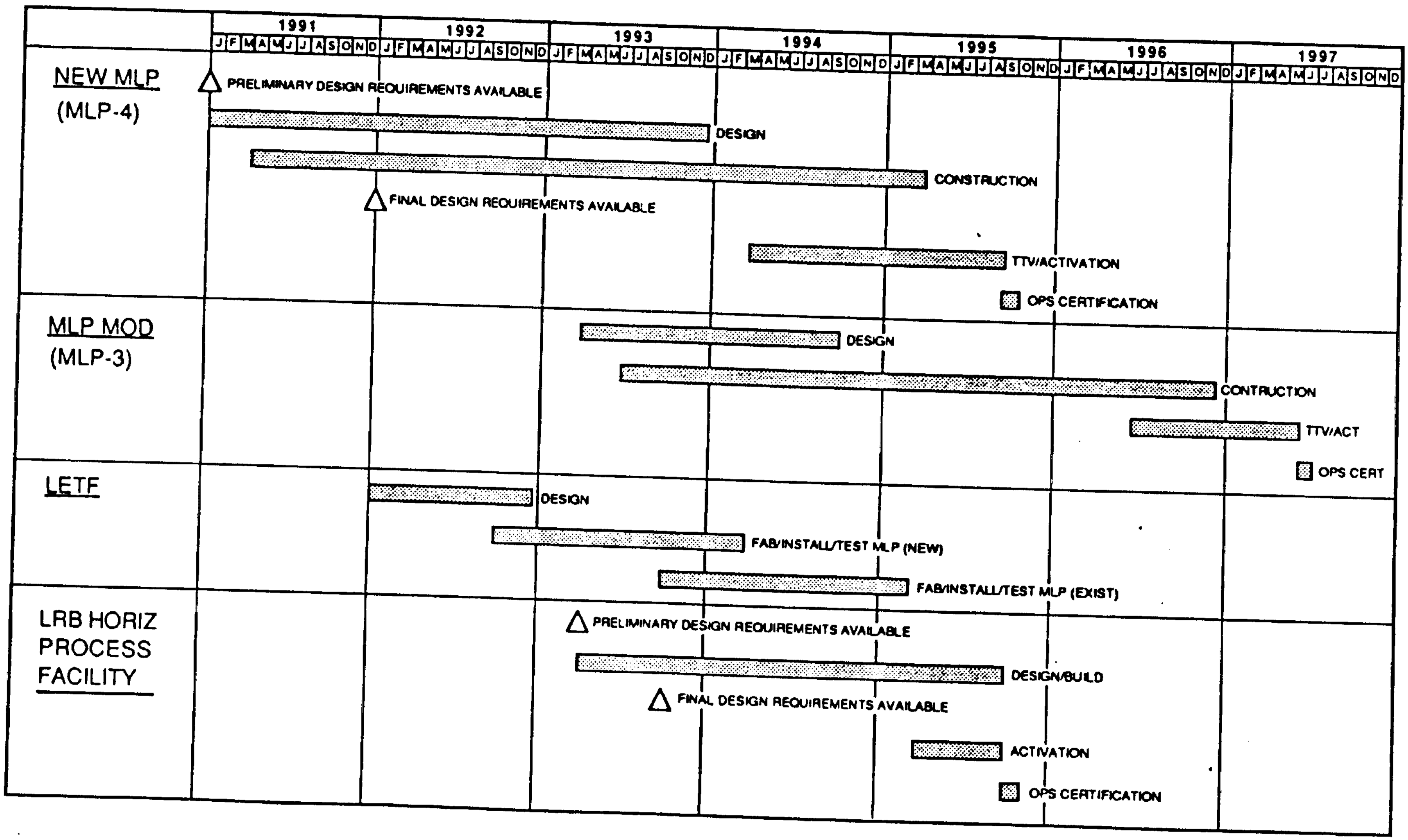
LRB INTEGRATION STUDY
KSC FACILITY
ACTIVATION SCHEDULE

APRIL 21, 1988
G. ARTLEY/L.P. SCOTT



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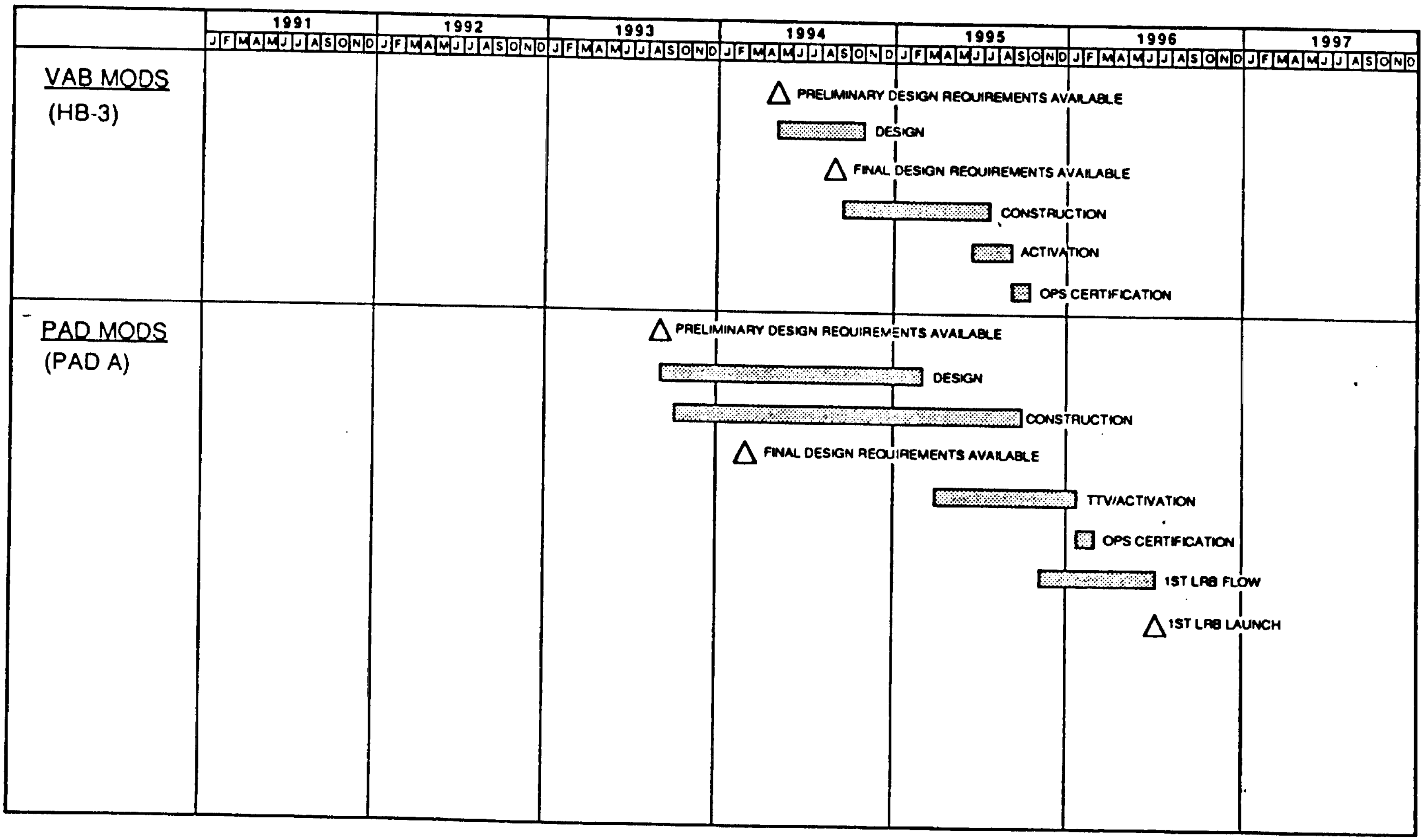
LRB INTEGRATION STUDY
KSC FACILITY
ACTIVATION SCHEDULE

APRIL 21, 1988
G. ARTLEY/L.P. SCOTT



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NEW LRB HORIZONTAL PROCESS FACILITY

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- OFFLINE STAND ALONE CHECKOUT / NO VAB INTERFERENCE
- RECEIVING / INSPECTION / TEST & CHECKOUT OPS
- ALL PROCESSING ON DELIVERY TRANSPORTER
- NEW GSE / TEST EQUIPMENT / TOWING TUG
- STAND ALONE LPS / CONTROL SYSTEM
- WORKSTANDS / ACCESS PLATFORMS / HORIZONTAL ENGINE CHANGEOUT
- CONTINGENCY ENGINE SERVICE SHOP
- NEW BATTERY LAB / CONTINGENCY AVIONICS SERVICE
- NEW LRB LOGISTICS SUPPORT REQUIRED
- SURGE / STORAGE CAPABILITY REQUIRED
- OFFLINE REPAIRS / MODS / LRU CHANGE OUT PROVISIONS

VAB MODS SUMMARY

APRIL 21, 1988
L. SCOTT/G. ARTLEY

- INTEGRATION CELL PLATFORM REVISIONS
- NEW SERVICING EQUIPMENT / GSE
- NEW ROTATION AND LIFTING FIXTURES
- ET MATE, ORBITER MATE PROCEDURES UNCHANGED
- NO HIGHBAY STRUCTURAL MODS OR DOOR MODS

MLP DESIGN APPROACH / ISSUES

APRIL 21, 1988
L. SCOTT/G. ARTLEY

- NO LAUNCH UMBILICAL TOWERS
- NEW LIFT-OFF UMBILICAL DESIGN
- NEW LPS INTERFACE / HIMs
- ENGINE REMOVAL / REPLACEMENT PROVISIONS
- NEW HOLDDOWN SYSTEM DESIGN
- NEW PROPELLANT LOADING / VALVES / CONTROL SYSTEM
- NEW BOOSTER FLAME HOLES / PLUME CLEARANCES
- REDESIGN: POWER / HGDS / INSTRUMENTATION / LPS / COMM
- REVISED WATER DELUGE / SOUND SUPPRESSION / FIREX SYSTEMS

PAD DESIGN APPROACH / ISSUES

APRIL 21, 1988
L. SCOTT/G. ARTLEY

- NO ADDED TOWERS / SWING ARMS
- NO LRB HYDRAZINE, HYDRAULICS REQUIREMENTS
- ON BOARD LOX VENT SYSTEM (NO COOLIE CAP)
- NEW FUEL SYSTEM (RP-1, CH_4, ETC)
- AUGMENTED LOX STORAGE SYSTEM / PUMPING SYSTEM REQUIRED
- NEW DESIGN FLAME DEFLECTOR / FLAME TRENCH MOD
- REVISED WATER DELUGE / DEFLECTOR, TRENCH COOLING
- REVISED MLP-TO-PAD INTERFACE
- MODIFIED ACCESS PROVISIONS: LRB AFT SKIRT, INTERTANK, FORWARD ASSEMBLY

LCC MODS SUMMARY

APRIL 21, 1988
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- NEW FIRING ROOM CONFIGURATION / REVISED CONSOLES
- NEW LRB GROUND SOFTWARE DEVELOPMENT / VERIFICATION
- NEW SAFING / ABORT PROVISIONS
- NEW LRB OMIs AND AUTOMATED LOADING PROCEDURES
- NEW COMM PROVISIONS / OTV
- NEW PHOTO-OPTIC CONTROL / TIMING DESIGN
- RF DOWNLINK (?)
- REVISED INTEGRATION / SAFING CONSOLES
- SIMPLIFIED ORBITER I/F REQUIRES EXTENSIVE LRB HEALTH MONITORING SYSTEMS CHECKOUT

LIQUID ROCKET BOOSTER (LRB)
KSC IMPACT

APRIL 21, 1988
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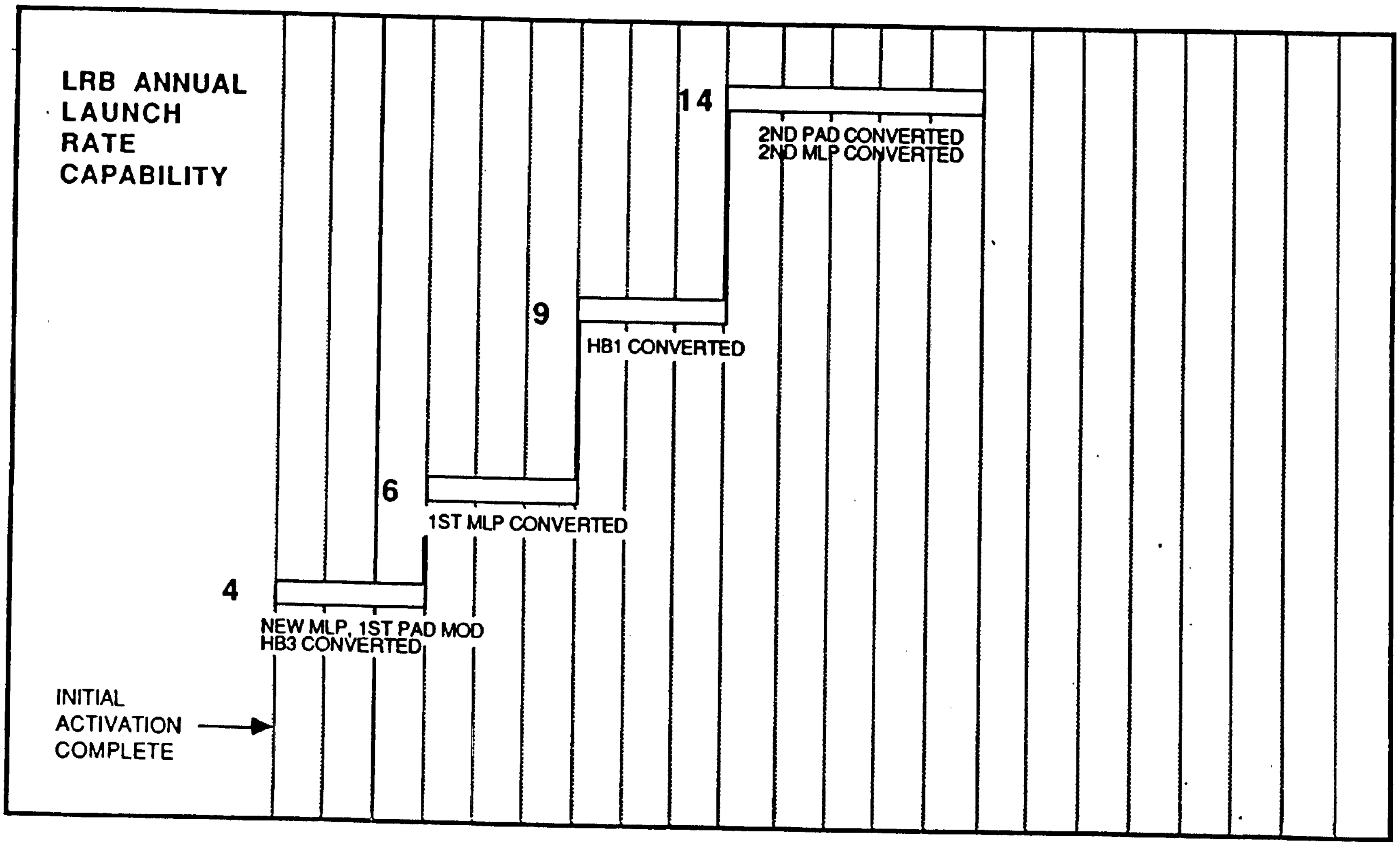

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KSC ADVANCED PROJECTS & TECHNOLOGY OFFICE

INDEX TO DRAWING 79K20788

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△B 1. PCR ELEVATIONS AND DRAWING INDEX
△A 1A. PLATFORM GUIDE RAIL PLANS I
△A 1B. PLATFORM GUIDE RAIL PLANS II
△B 1C. GENERAL ARRANGEMENT PLAN
△B 2. ACCESS PLATFORMS - PLAN AND ELEVATIONS
3. ACCESS PLATFORMS - REMOV. HANDRAILS - DETAILS
△B 4. ACCESS PLATFORMS - GUIDE/SLIDE SHOE ASSEMBLIES
△B 5. OAA HINGED GUIDE RAIL - LIFTING BOOM
△B 5A. OAA HINGED GUIDE RAIL - LIFTING BOOM DETAILS
△A 6. PLATFORM WINCHING SYSTEM - PLANS AND DETAILS
△A 7. PLATFORM WINCHING SYSTEM - SHEAVE MOUNTING DETAILS
△A 8. PLATFORM WINCHING SYSTEM - JIB FRAMING DETAILS
△A 8A. PLATFORM WINCHING SYSTEM - AIR WINCH PIPING SCHEMATIC ISOMETRIC
9. -Y FIXED GUIDE RAIL - DETAILS
10. +Y FIXED GUIDE RAIL - DETAILS
11. -Y PIVOTED GUIDE RAIL - PLANS AND ELEVATIONS

C-3

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INDEX TO DRAWING 79K20788

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- △B 12. OAA HINGED GUIDE RAIL - DETAILS
- △B 13. PLATFORM ACCESS LADDER DETAILS
- △B 14. GUIDE RAIL BRACING - DETAILS I
- 15. GUIDE RAIL BRACING - DETAILS II
- △B 16. OAA HINGED GUIDE RAIL - LATCH AND PIN
- △B 17. +Y HINGED GUIDE RAIL - HINGE AND LIFTING CONNECTION
- △B 18. OAA HINGED GUIDE RAIL - LATCH AND PIN DETAILS
- △B 19. MISCELLANEOUS DETAILS
- 20. -Y HINGED GUIDE RAIL EXTENSION - GENERAL ARRANGEMENT
- 21. RCS ROOM/ACCESS PLATFORM - SERVICE FLIP-UP
- △B 22. +Y HINGED GUIDE RAIL - EXTENSION
- 23. +Y HINGED GUIDE RAIL EXTENSION - HINGE ASSY.
- △B 24. +Y HINGED GUIDE RAIL EXTENSION LIFTING SYSTEM
- 25. -Y PIVOTED GUIDE RAIL - DETAILS I
- △A 26. +Y HINGED GUIDE RAIL EXTENSION - LIFTING SYSTEM DETAILS
- 27. -Y PIVOTED BUIDE RAIL - DETAILS II
- 28. -Y PIVOTED GUIDE RAIL - THRUST BEARING BRACKET

▒ NOT IN CONTRACT

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INDEX TO DRAWING 79K20788

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29. -Y PIVOTED GUIDE RAIL - RADIAL HINGE
30. -Y PIVOTED GUIDE RAIL - THRUST BEARING HINGE
31. -Y PIVOTED GUIDE RAIL - RADIAL HINGE BRACKET
32. +Y FRAMING CONNECTION DETAILS
33. B +Y HINGED GUIDE RAIL EXTENSION - ACCESS CATWALK
34. -Y HINGED GUIDE RAIL EXTENSION - DETAILS I
35. -Y HINGED GUIDE RAIL EXTENSION - DETAILS II
36. -Y HINGED GUIDE RAIL EXTENSION - DETAILS III
37. -Y HINGED GUIDE RAIL EXTENSION - DETAILS IV
38. -Y HINGED GUIDE RAIL EXTENSION - DETAILS V
39. -Y HINGED GUIDE RAIL EXTENSION - DETAILS VI
40. -Y HINGED GUIDE RAIL EXTENSION - DETAILS VII
41. B RAIN WATER RUNOFF DRAIN - I
42. B RAIN WATER RUNOFF DRAIN - II
43. B AFT IEA ACCESS PLATFORM FOR RIGHT SRB
44. B AFT IEA ACCESS PLATFORM FOR RIGHT SRB - SECTIONS AND DETAILS

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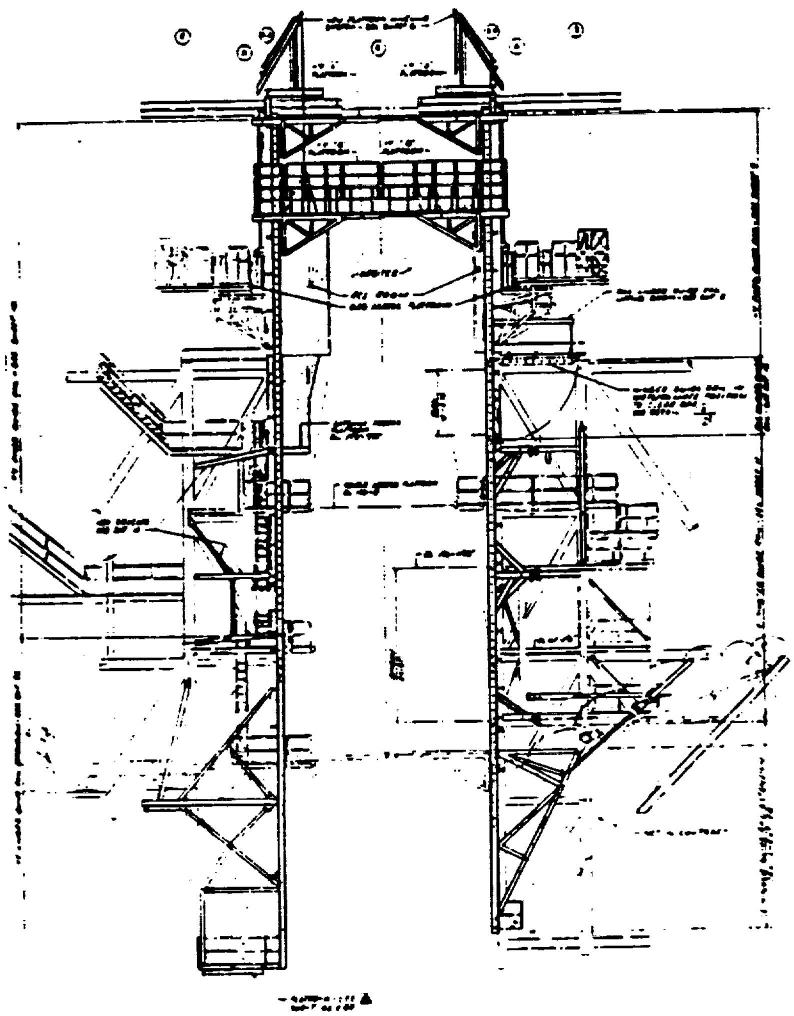

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ET/ORBITER ADJUSTABLE ACCESS PLATFORMS

National Aeronautics and Space Administration - John F. Kennedy Space Center
Kennedy Space Center, Florida

NASA

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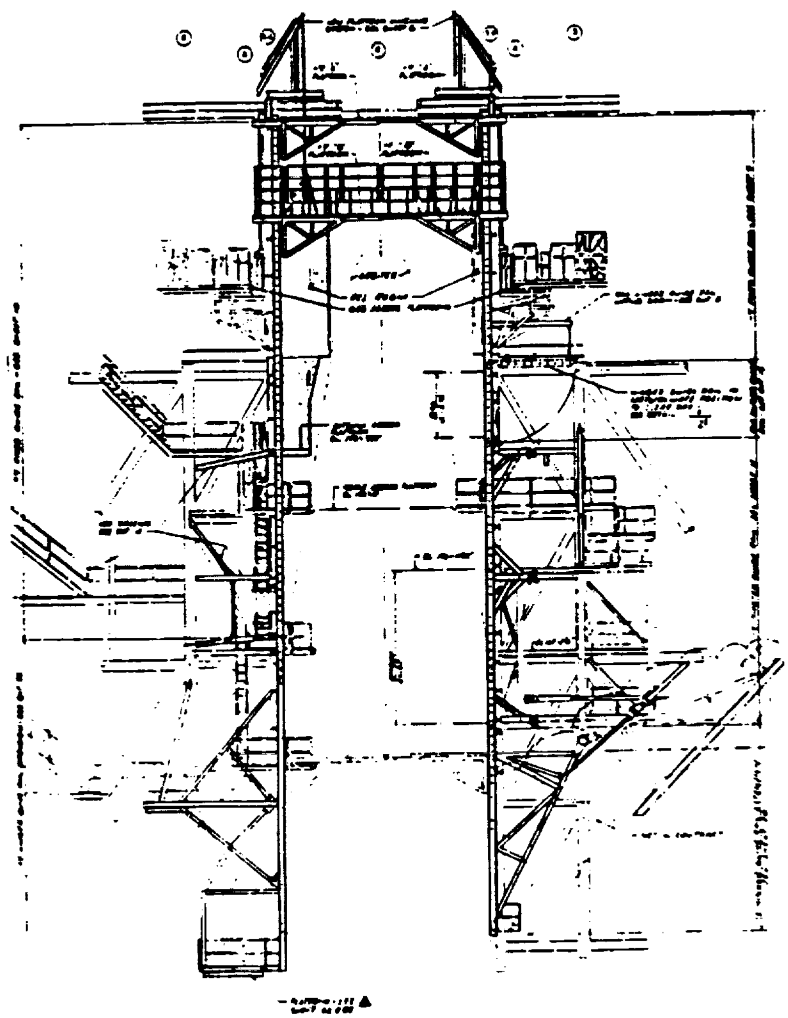

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ET/ORBITER ADJUSTABLE ACCESS PLATFORMS

National Aeronautics and Space Administration - John F. Kennedy Space Center
Kennedy Space Center, Florida

NASA

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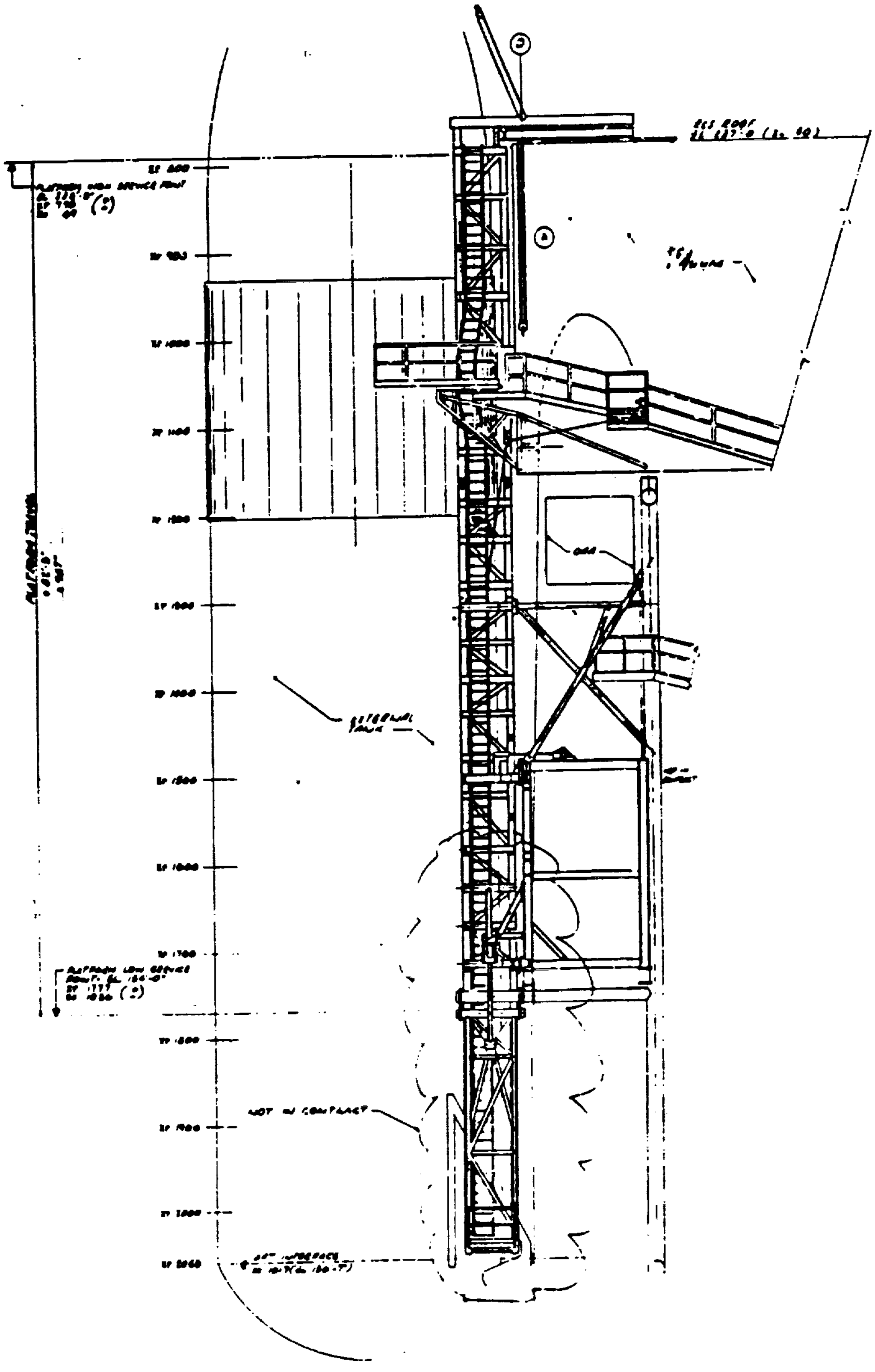

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ET/ORBITER ADJUSTABLE ACCESS PLATFORMS

National Aeronautics and Space Administration - John F. Kennedy Space Center
Kennedy Space Center, Florida

NASA

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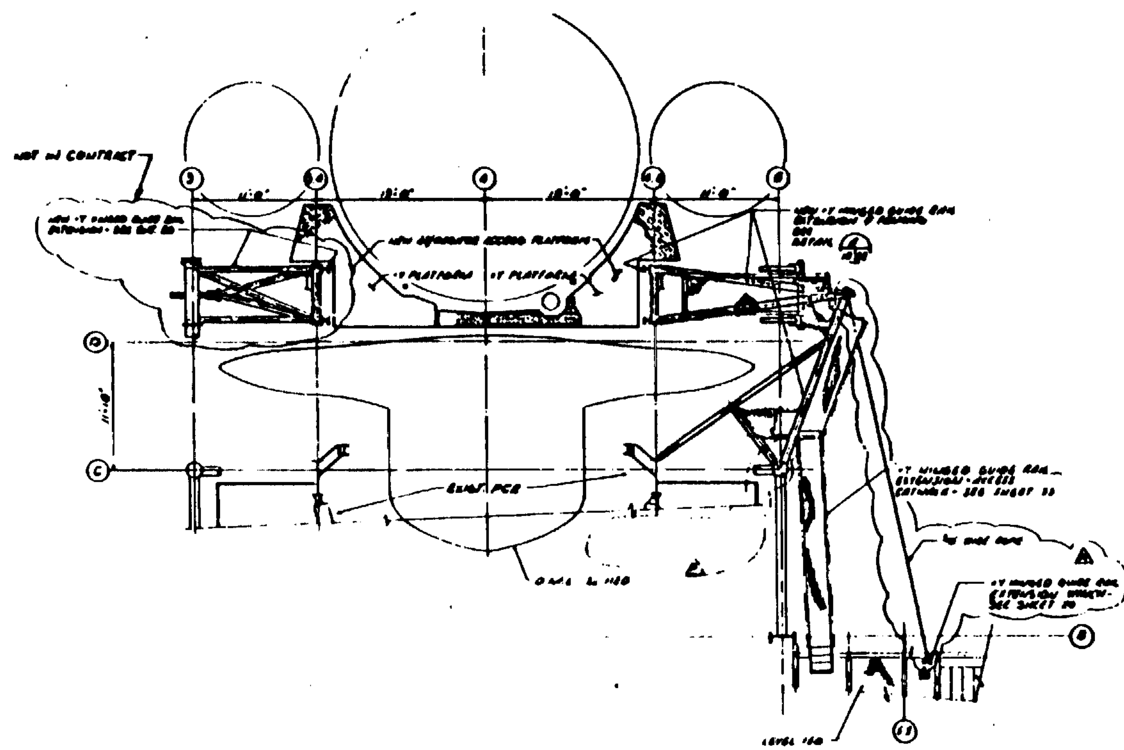

PLAN - EL 148'-4" (TOP OF STEEL)
3/16" = 1'-0"

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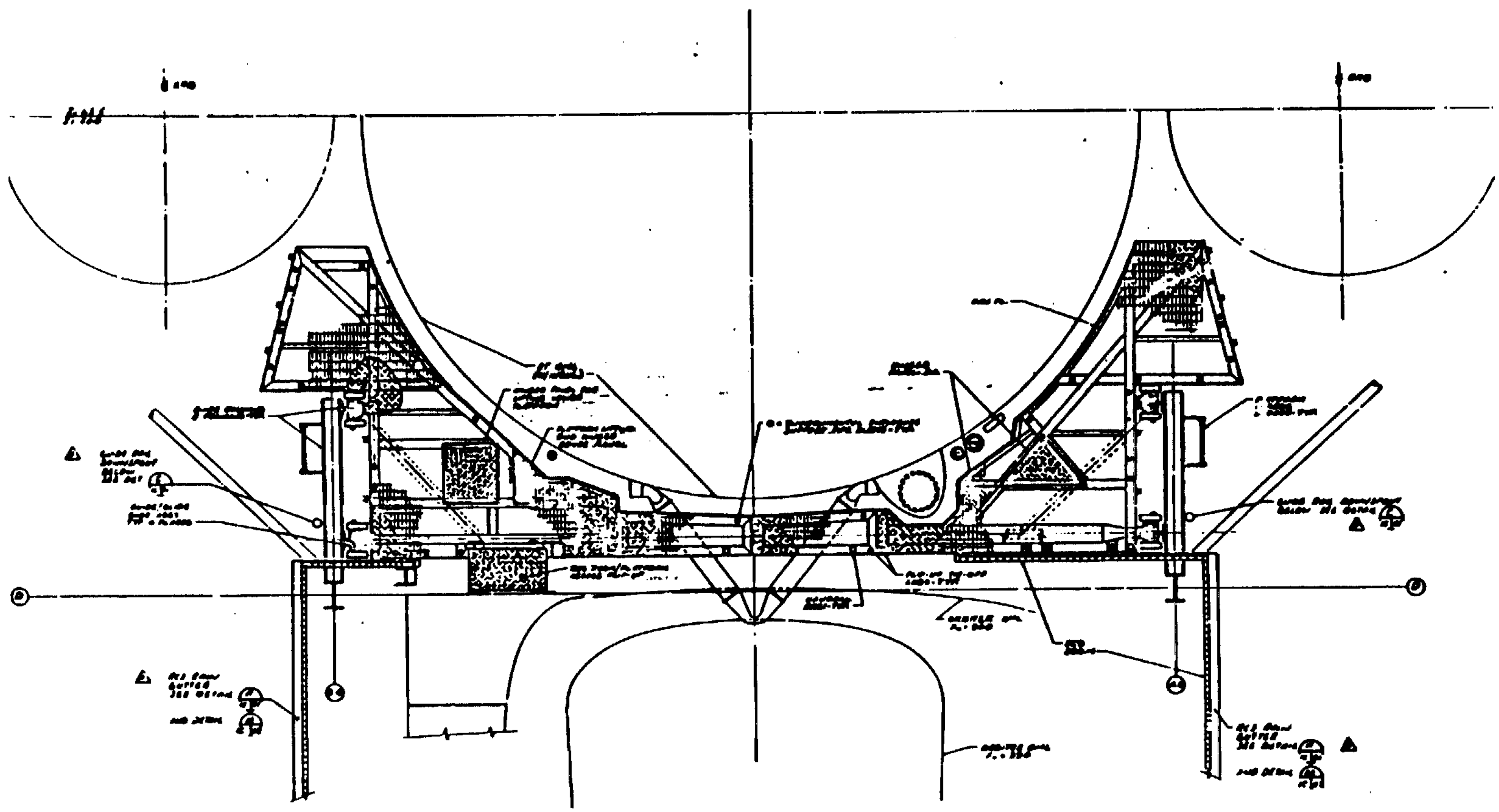

PLAN - GENERAL ARRANGEMENT - ET - ORBITER - RCS ROOM FOR ORBITER/ET ADJUST ACCESS PLATFORMS

1" x 20'

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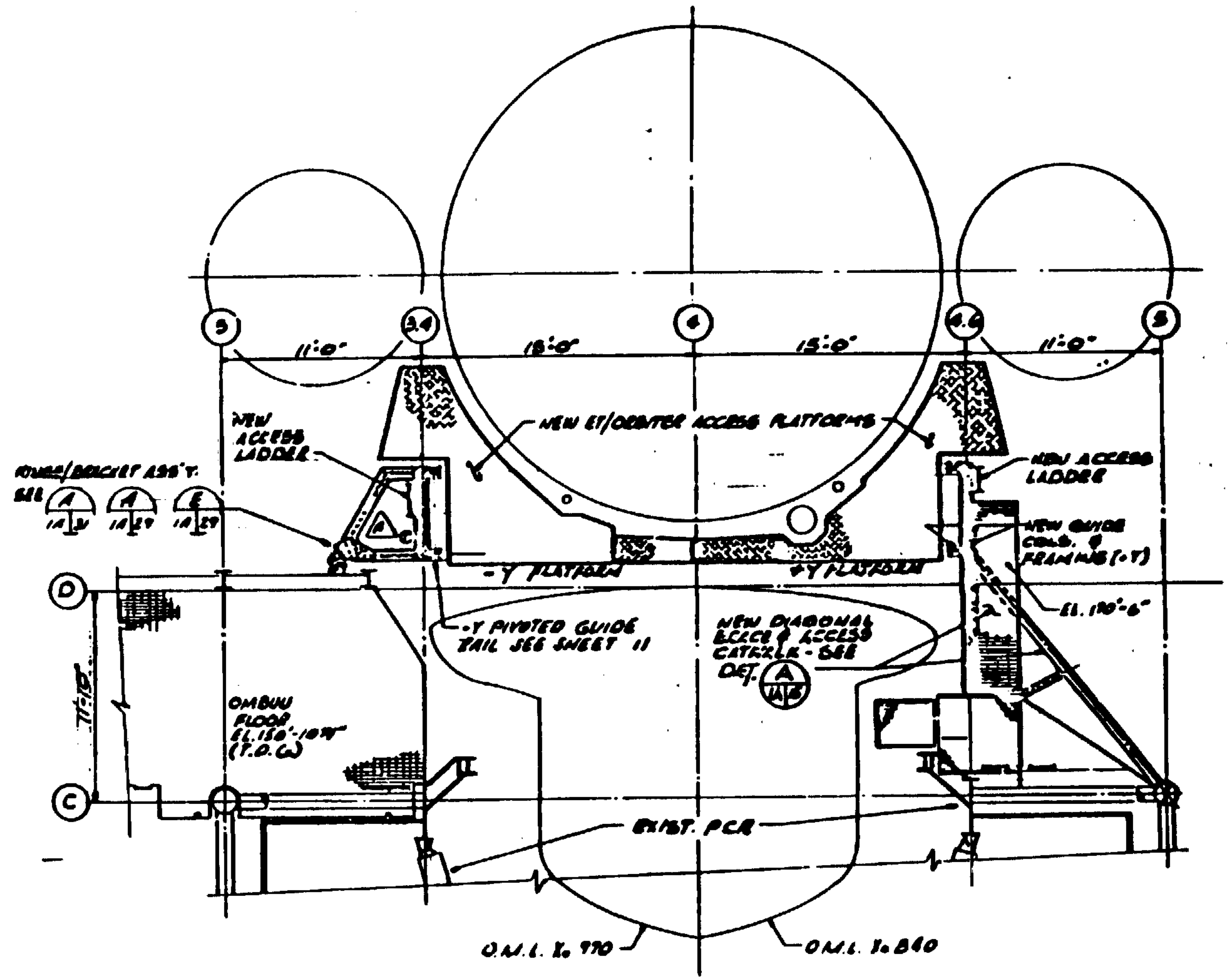

PLAN AT OMBUU FLOOR - EL 158' - 10 1/4" AND EL 170' - 6"
3/16" = 1'-0"

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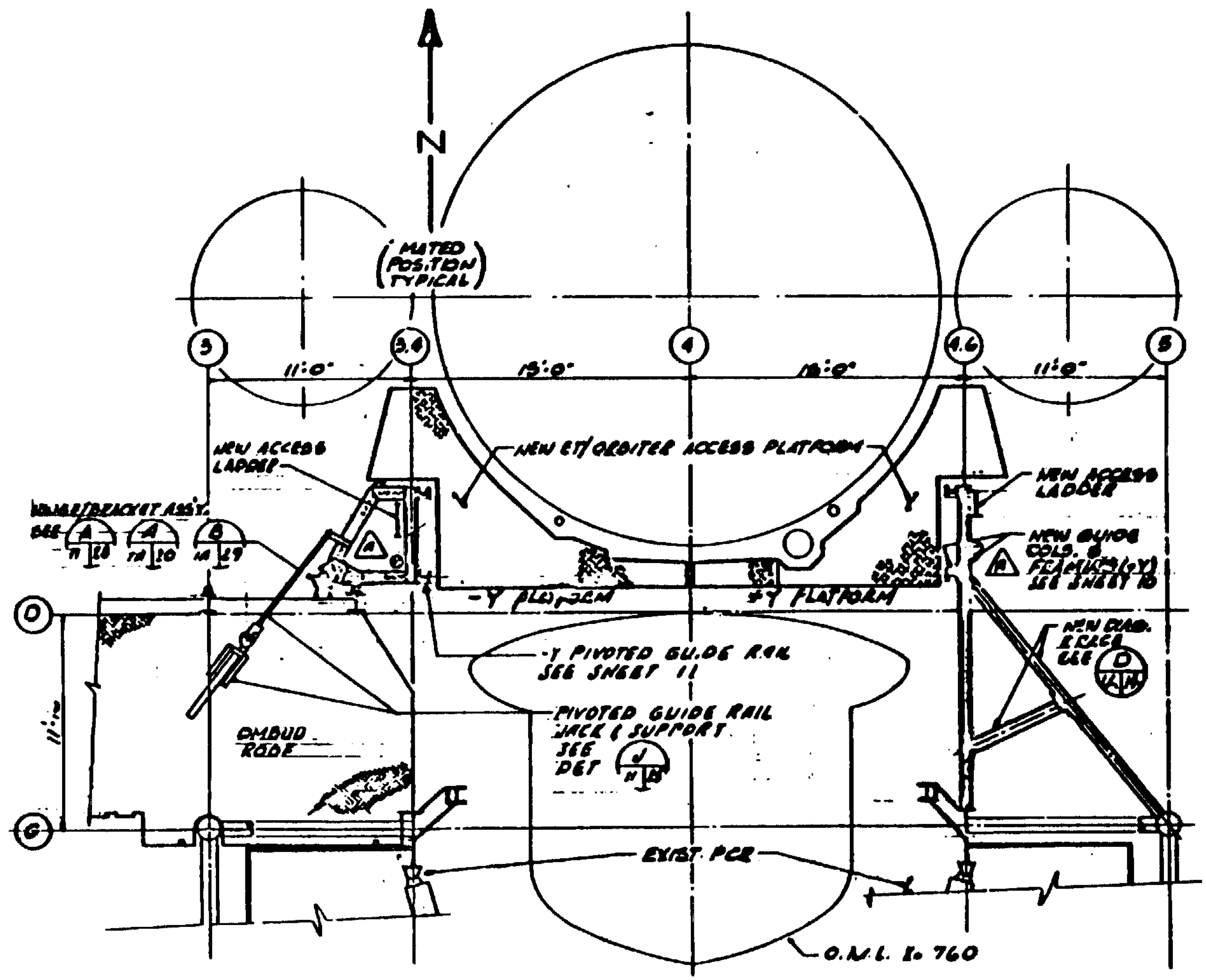

PLAN AT TOP OF OMBUU - EL 176' - 11 3/8"

3/16" = 1'-0"

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APRIL 21, 1988
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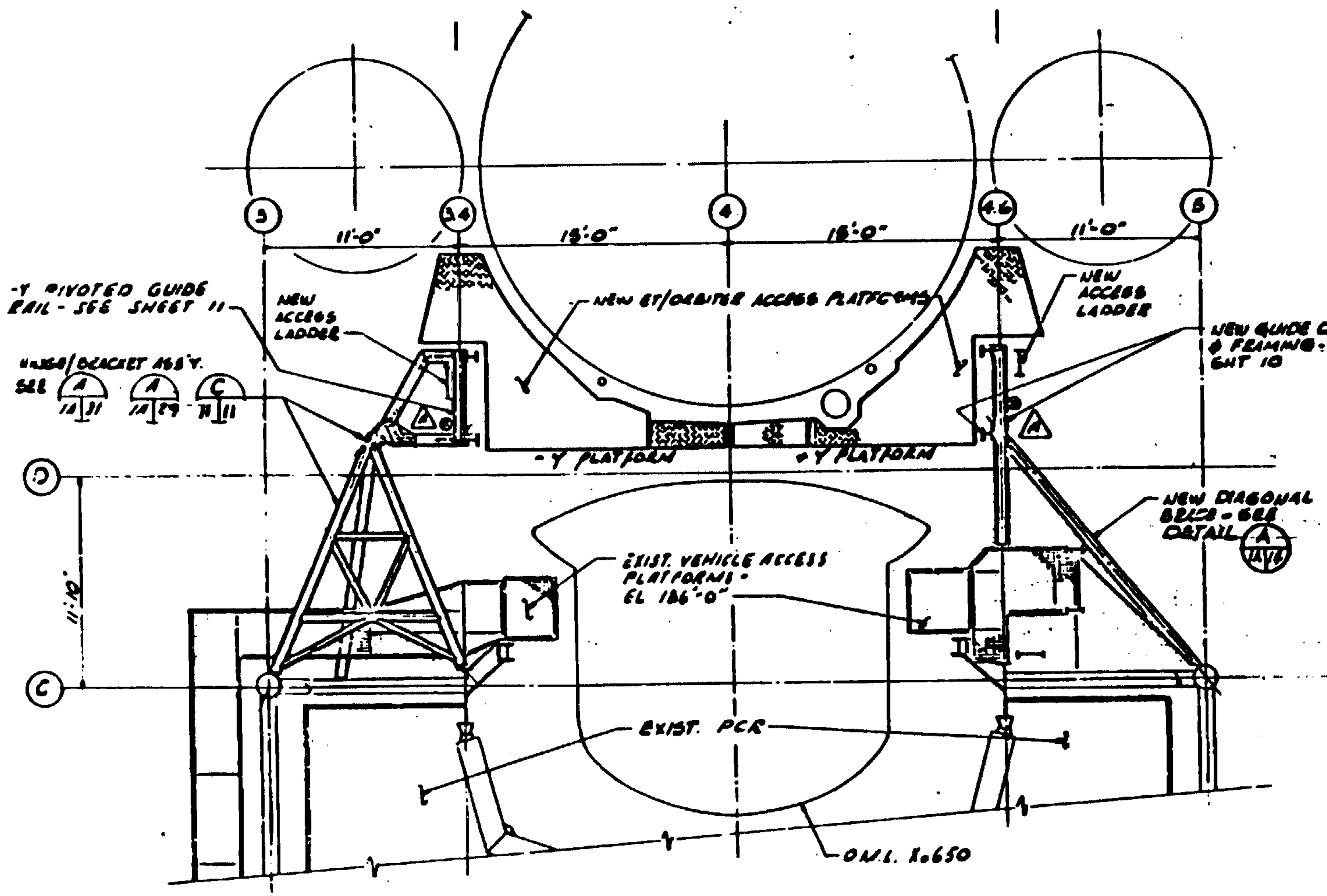

PLAN AT ACCESS PLATFORMS - EL 186' - 0"

3/16" = 1'-0"

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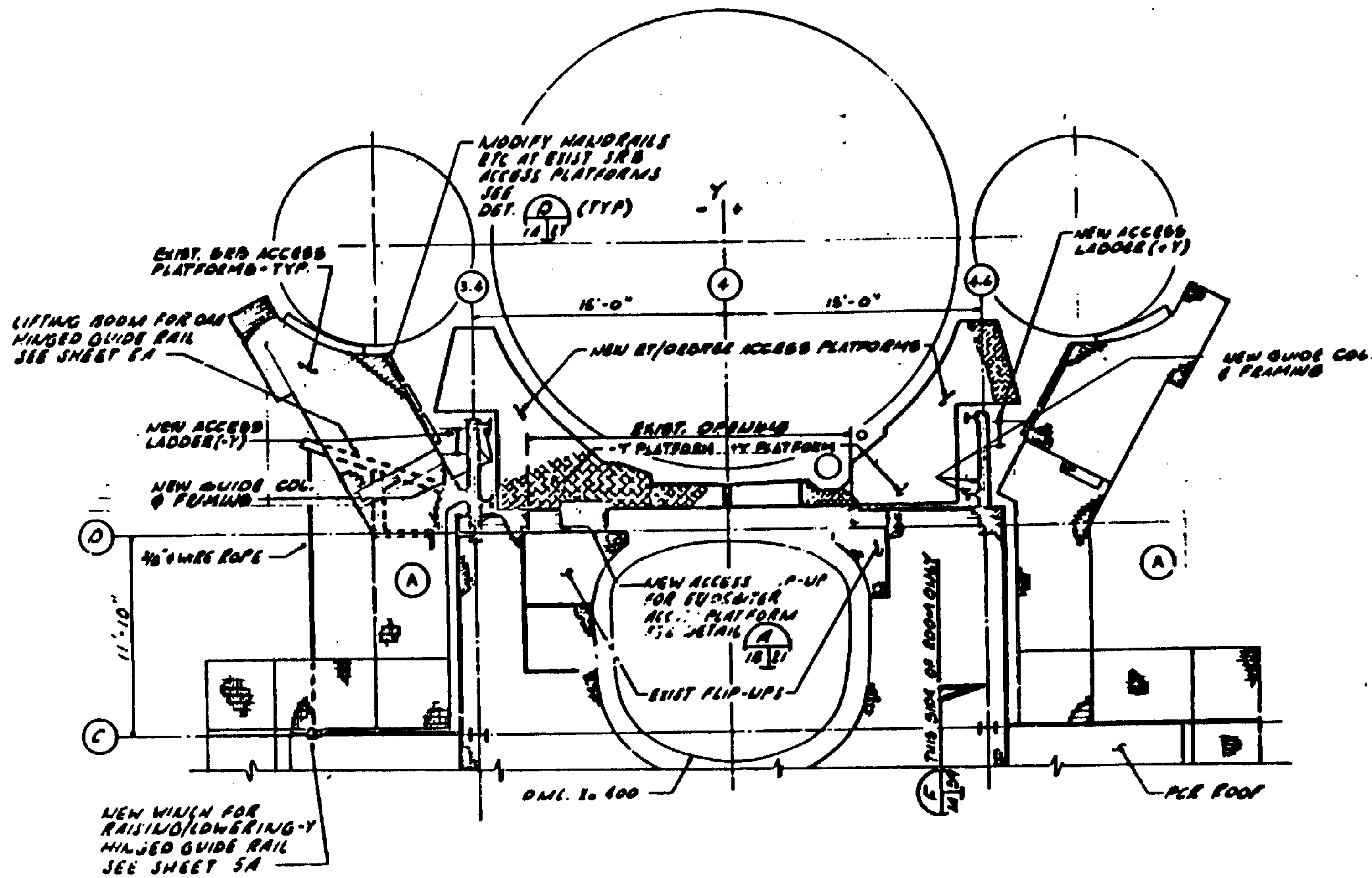

PLAN - RCS ROOM FLOOR - EL 207' - 2"

3/16" = 1'-0"

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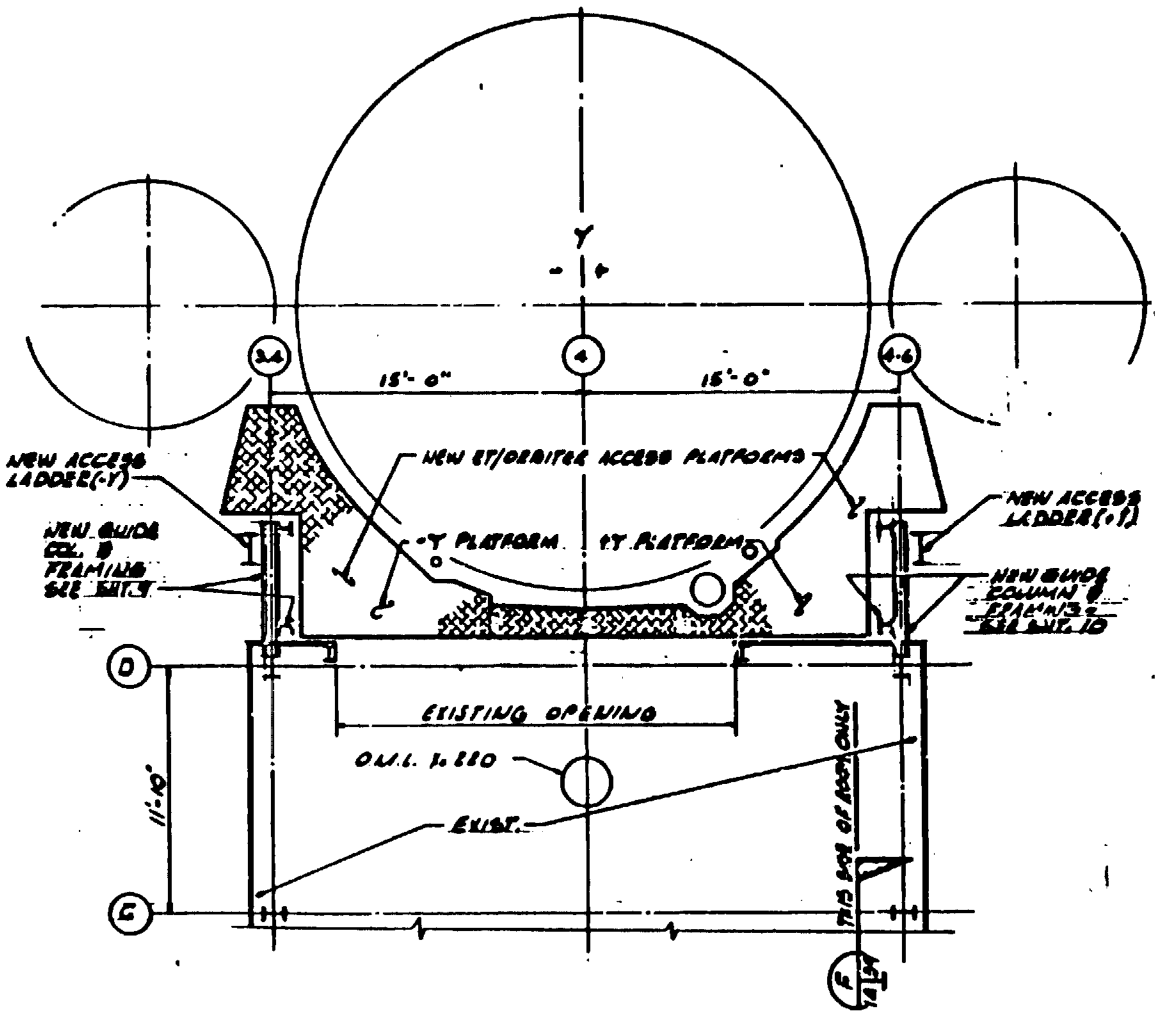

PLAN IN RCS ROOM - EL 222' - 0"

3/16" = 1'-0"

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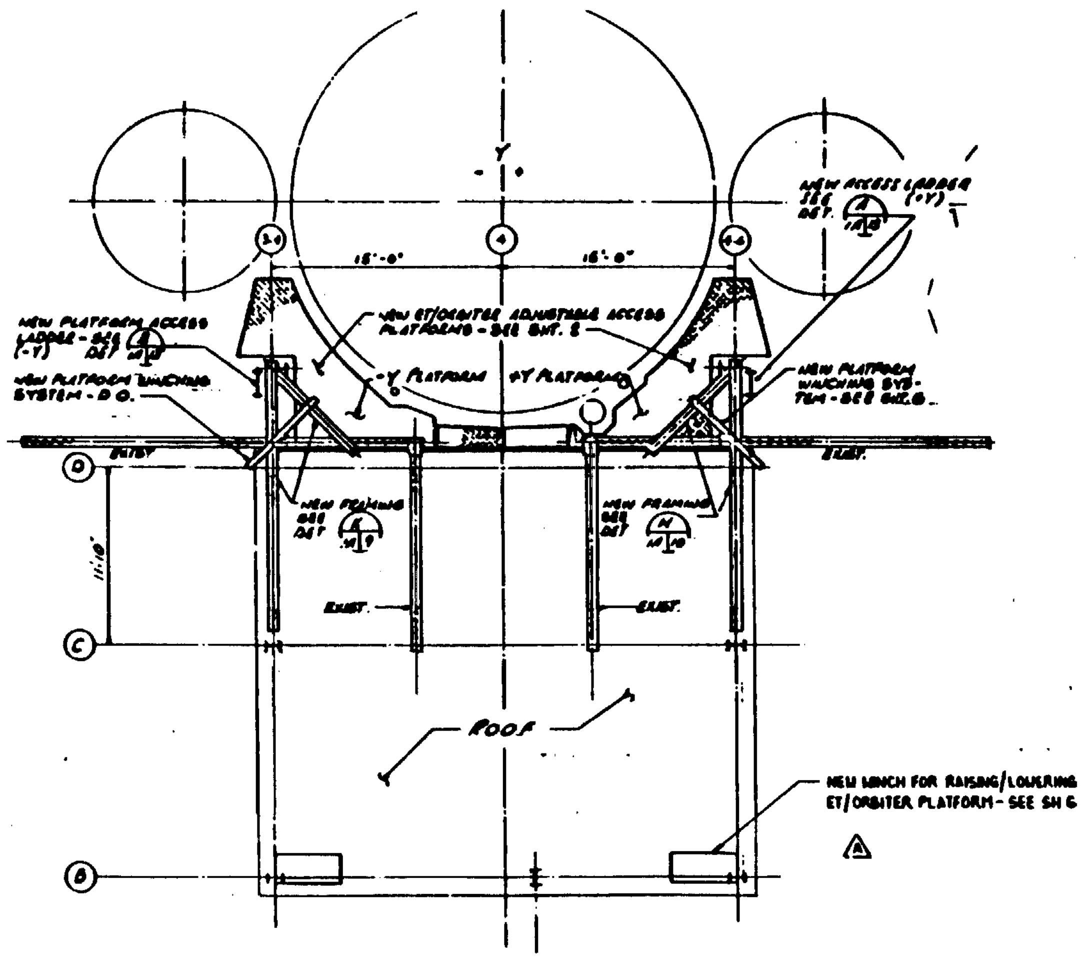
APRIL 21, 1988
G. ARTLEY



PLAN IN RCS ROOM ROOF

3/16" = 1'-0"

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VOLUME IV

SECTION 4

COST WORKING GROUP MEETING

MAY 10, 1988

81005-01BM24d

KSC ADVANCED PROJECTS & TECHNOLOGY OFFICE

LIQUID ROCKET BOOSTER (LRB) KSC IMPACTS

MAY 10, 1988

KSC COST ASSESSMENTS FOR LRB

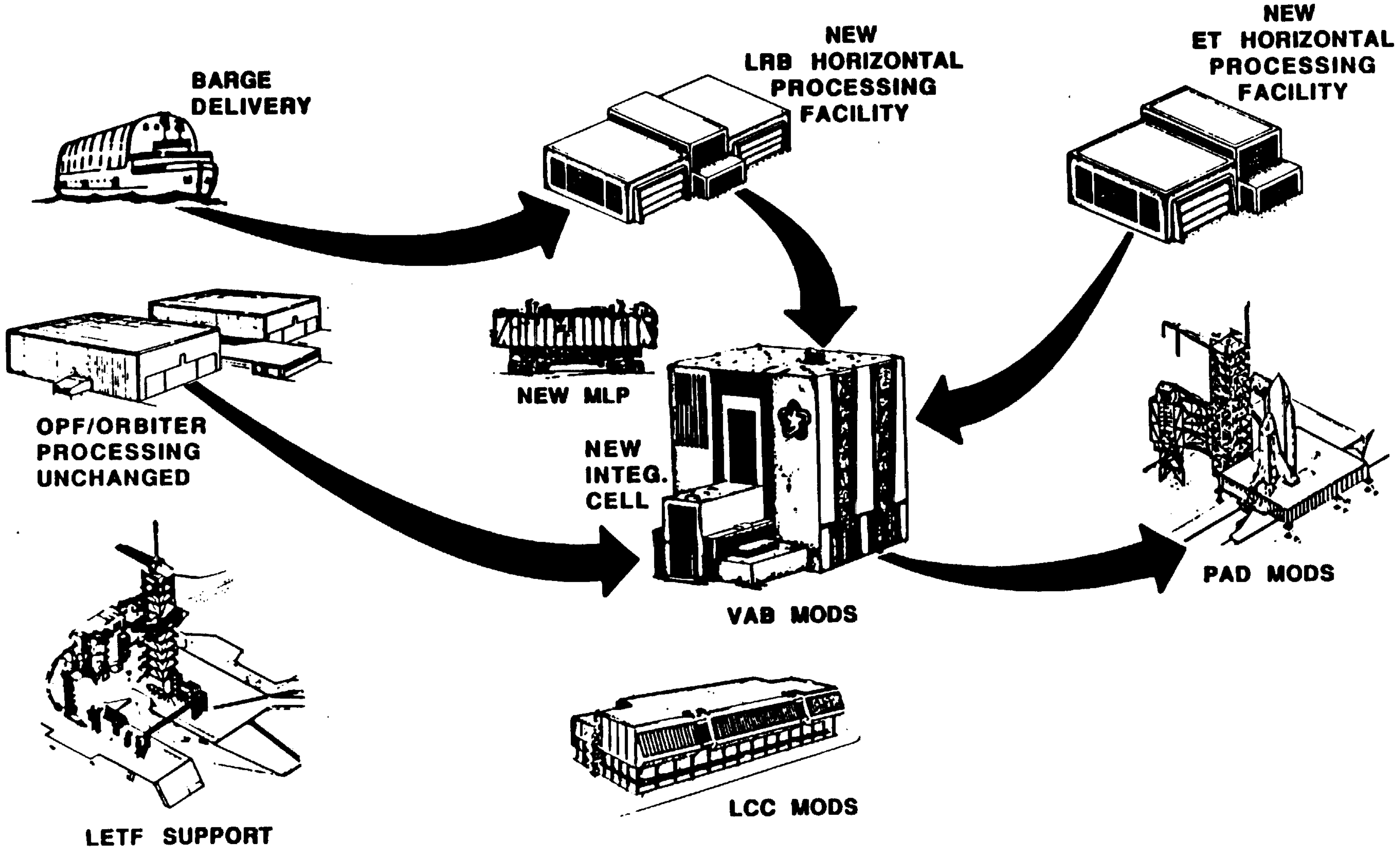
- **OUTLINE:**
  - LRB PROCESSING SCENARIO
  - COSTING GROUNDRULES / DATA SOURCES
  - COST ELEMENT BREAKDOWN
  - COST DATA SUMMARY
  - TRANSITION ISSUES / WORK IN PROGRESS

KSC ADVANCED PROJECTS & TECHNOLOGY OFFICE

LIQUID ROCKET BOOSTER (LRB) KSC IMPACTS

MAY 10, 1988

LRB PROCESSING SUMMARY



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LIQUID ROCKET BOOSTER (LRB)
KSC IMPACTS

MAY 10, 1988

LRB PROCESSING SUMMARY

SCENARIO GROUNDRULES: (GENERAL)

- LRB TRANSITION IS PLANNED TO YIELD MIN IMPACTS TO ON-GOING KSC FLIGHT OPS
- FIRST-LINE FACILITY ACTIVATIONS WILL SUPPORT 1996 FIRST FLIGHT AND A BUILD-UP TO AN ANNUAL 4 LRB LAUNCH RATE
- A FIVE-YEAR TRANSITION TO FULL FLIGHT RATE OF 14 IS PLANNED OVER 1996 TO 2000. SECOND AND THIRD LINE FACILITY ACTIVATIONS ARE PLANNED TO SUPPORT THIS BUILD-UP
- SHARED FACILITY UTILIZATION FOR THE MIXED FLEET OPS ARE PLANNED TO SUPPORT SHUTTLE LAUNCH MANIFEST DURING TRANSITION

LIQUID ROCKET BOOSTER (LRB) KSC IMPACTS

MAY 10, 1988

KSC COST ELEMENT BREAKDOWN

NON-RECURRING

1. FIRST-LINE FACILITY ACTIVATION FOR IOC
   - LRB HORIZ PROCESS FAC
   - NEW MLP
   - VAB HB4 MOD
   - PAD MOD
   - LETF / LCC MOD

   ELEMENTS: DESIGN, CONSTRUCTION, *TTV / ACTIVATION, OPS CERTIFICATION / VALIDATION

2. SECOND / THIRD-LINE FACILITY ACTIVATION FOR TRANSITION
   - 2ND MLP (MOD EXISTING)
   - 2ND INTEG CELL (MOD HB3)
   - 3RD MLP (MOD EXISTING)
   - 2ND PAD MOD

   ELEMENTS: DESIGN, CONSTRUCTION, *TTV / ACTIVATION, OPS CERTIFICATION / VALIDATION

3. GSE AND LSE (ALL SITES)

4. GROUND SOFTWARE / LPS DEVELOPMENT

5. ORBITER / ET MODS TO ACCOMMODATE LRB

* TTV = TERMINATE, TEST AND VERIFICATION

LIQUID ROCKET BOOSTER (LRB)
KSC IMPACTS

MAY 10, 1988

KSC COST ELEMENT BREAKDOWN

RECURRING

6. BOOSTER PROCESSING MANPOWER
   - TECHNICIANS
   - ENGINEERING
   - QUALITY / SAFETY
   - PLANNING / SCHEDULING
   - TRAINING / CERTIFICATION

7. OPERATIONS SUPPORT MANPOWER *
   - LOGISTICS SUPPORT - SPARES PROVISIONING
   - BASE OPERATIONS (EG&G)
   - FACILITY AND GSE O&M
   - COMM
   - LPS / SOFTWARE

8. ON-GOING LRB MODIFICATIONS

NOTE: LRB PROCESSING MANPOWER BASED ON A POST-IOC ASSESSMENT WITH NO LEARNING CURVE CURRENTLY APPLIED.

* NASA/KSC CIVIL SERVICE ALLOTTED COST ARE INCLUDED IN OPERATIONS SUPPORT MANPOWER

KSC ADVANCED PROJECTS & TECHNOLOGY OFFICE

LIQUID ROCKET BOOSTER (LRB) KSC IMPACT

MAY 10, 1988

LRB LAUNCH SITE COST ELEMENTS

(1) NON-RECURRING		DESIGN	CONSTRUCTION	TTV ACTIVATION	OPS CERTIFICATION	TOTAL COST (M)
FIRST LINE FACILITIES	MLP	5.6	62	21.8	1.6	$91
	LRB HORIZ. PROC. FAC.	1.0	13.5	1.7	0.8	$17
	VAB MOD (HB-4)	0.8	10.0	1.2	1.0	$13
	PAD MOD (A OR B)	3.3	37	14	1.7	$56
	LETF / LCC	0.5 / 2.0	6.3 / 3.0	—	1.2 / 1.0	$8 / $6
	ET HORIZ PROC FAC	0.8	11.0	1.4	0.8	$14

TOTAL = $205M

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Lockheed Space Operations Company

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LIQUID ROCKET BOOSTER (LRB) KSC IMPACT

MAY 10, 1988

LRB LAUNCH SITE COST ELEMENTS

② NON-RECURRING		DESIGN	CONSTRUC-TION	TTV ACTIVATION	OPS CERTIFI-CATION	TOTAL COST (M)
SECOND/THIRD LINE FACILITIES	2ND MLP (MOD)	3.0	35.5	13.2	1.3	$53
	VAB HB-3 MOD	0.2	2.4	0.3	0.1	$3
	PAD MOD	3.3	37	14	1.7	$56
	3RD MLP (MOD)	3.0	35.5	13.2	1.3	$53
	LETF / LCC	0.5 / 0.5	1.0 / 1.5	—	3.5 / 1.0	$5 / $3

TOTAL = $173M

LIQUID ROCKET BOOSTER (LRB) KSC IMPACT

MAY 10, 1988

LRB LAUNCH SITE COST ELEMENTS

3 NON-RECURRING

GSE/LSE (ALL SITES)	HANDLING FIXTURES	ENGINE GSE	LEAK PRESSUR.	ELEC C-0	ACCESS	OTHER MECH.	TOTALS (M)
HORIZ. PROC. FAC.	3	10	2	10	2	1	$28
MLP's (3)	5	20	5	15	3	2	$50
VAB (2)	1	2	~	5	1	~	$9
PAD's (2)	~	3	1	2	1	1	$8
ET PROC. FAC.	1	~	1	~	1.5	~	$3.5
TOTALS (M)	$10	$35	$9	$32	$8.5	$4	$98.5M

LIQUID ROCKET BOOSTER (LRB) KSC IMPACT

MAY 10, 1988

LRB PROCESSING MANHOURS AND COST

SKILL MIX	RATIO	MANHOURS	COST
LRB PROCESSING		11,744	
VAB OPS		3,632	
PAD OPS		4,680	
TOTAL TECHNICIANS	1.00	20,056	$ 355,392
ENGINEERING	0.89	17,850	366,814
FAC & GROUND SUPPORT	1.14	22,864	393,258
LOGISTICS	0.53	10,630	172,095
QUALITY	0.38	7,621	139,393
SAFETY	0.08	1,604	29,346
PP&C	0.22	4,412	78,892
OVERHEAD	0.42	8,424	162,574
GRUMMAN	0.71	14,240	281,235
SUBTOTAL		107,701	$1,979,000
BASE SUPPORT - EG&G	1.60	32,090	$513,434
NASA - CS	1.92	38,508	847,165
SUBTOTAL		70,598	$1,360,599
GRAND TOTAL		178,298	$3,339,599

COMMENTS AND ASSUMPTIONS:

1. MHRS AND COST FOR PROCESSING LRBs FROM RECEIPT THRU LAUNCH
2. ALL SKILL MIXES ARE RATIOED TO TECHNICIANS
3. MHRS AND COST ARE BASED ON THE LRB PROCESSING FLOW
4. EG&G BASE SUPPORT ASSUMES 20% SUPPORTS CARGO AND 80% SUPPORTS SHUTTLE ELEMENT PROCESSING
5. THE NASA/KSC CIVIL SERVICE VALUES HAVE THE SAME ASSUMPTIONS AS THE EG&G BASE SUPPORT ASSUMPTION IN ITEM #4
6. A NON-RECOVERABLE LRB IS ASSUMED IN THE ABOVE TABLE

KSC ADVANCED PROJECTS & TECHNOLOGY OFFICE

LIQUID ROCKET BOOSTER (LRB) KSC IMPACT

MAY 10, 1988

CURRENT SRB PROCESSING MANHOURS AND COST

SRB ACTIVITY/LOC	MANHOURS *	COST *
SRB PROCESSING	18,603	$ 311,191
SRB STACKING	10,240	181,008
VAB INTEGRATION	5,095	88,728
PAD PROCESSING	18,575	343,842
SRB SHOPS/SE MAINT	3,378	$ 54,264
SRB OPS SUPPORT	6,898	179,466
INTEG OPS SUPPORT	7,961	164,167
RPSF - MAINT	2,818	$ 54,488
VAB - MAINT	4,639	90,196
PAD/MLP - MAINT	276	5,661
SAFETY	5,377	$ 114,630
OVERHEAD	4,183	90,407
SPC (LSOC) SUPPORT		
SRB PROCESSING	1,120	$ 23,016
SRB STACKING	784	16,111
VAB INTEGRATION	254	5,220
PAD PROCESSING	5,704	109,146
OPS SUPPORT	814	14,888
GRUMMAN	3,997	78,936
SUBTOTAL	100,716	$1,925,365
BASE SUPPORT - EG&G	32,090	513,434
NASA/KSC - CS	38,508	847,165
SUBTOTAL	70,598	$1,360,599
GRAND TOTAL	171,314	$3,285,964

* 95% CONFIDENCE

COMMENTS AND ASSUMPTIONS:

1. MORTON THIOKOL PROCESSING MANHOURS AND COST BASED ON THE PAST 14 MISSIONS
2. SPC (LSOC) DATA BASED ON THE PAST THREE MISSIONS
3. ALL SPC MANHOUR AND COST DATA IS PWO AND WBS DATA
4. EG&G AND NASA/KSC CS MANHOUR AND COST DATA ASSUMES 80% OF MANHOURS AND COST SUPPORTS SHUTTLE ELEMENT PROCESSING AND 20% SUPPORTS CARGO OPS AT KSC
5. ALL LSOC SUPPORT IS ENGINEERING MANHOURS EXCEPT 1/2 OF PAD PROCESSING AND THE OTHER HALF IS TECHS AND ALL OPS SUPPORT IS QUALITY PEOPLE

LIQUID ROCKET BOOSTER (LRB) KSC IMPACT

MAY 10, 1988

KSC SRB RETRIEVAL/ REFURBISHMENT	MANHOURS *	COST *
SRB RETRIEVAL/OPS	7,539	$ 153,164
SRB RETRIEVAL VESSEL	6,450	134,425
HANGAR AF OPS	12,379	247,195
USBI - KSC OPS	88,043	1,678,048
TOTAL	114,411	$2,212,832

* 95% CONFIDENCE

NOTES:

1. IT IS ASSUMED THE USBI - KSC OPS IS STAFFED APPROXIMATELY THE SAME AS MORTON THIOKOL AT 400 PEOPLE
2. THIS $2.2M SRB LAUNCH SITE COST IS AVOIDED BY THE USE OF EXPENDABLE LRBs

LIQUID ROCKET BOOSTER (LRB)
KSC IMPACT

MAY 10, 1988

KSC LIFE CYCLE COSTS FOR LRB

COST ELEMENT	UNIT COST	QTY	TIME SPAN	TOTAL
NON-RECURRING				
1. FIRST-LINE FACILITY	$ 205M	1	91-95	$ 205M
2. SECOND/THIRD-LINE FAC.	173M	1	96-00	173M
3. GSE/LSE	98.5M	1	91-95	98.5M
4. GROUND S/W - LPS	20M	1	91-95	20M
5. ORBITER/ET MODS	TBD	—	—	TBD
				$496.5M
RECURRING				
6. BOOSTER PROC. MANPOWER	$3.34M/FLOW	81	96-06	270.6M
7. OPERATIONS SUPPORT MANPOWER				(INCLUDED IN ABOVE)
8. ON-GOING LRB MODIFICATIONS	TBD	—	—	TBD

LCC GRAND TOTAL = $767.1M

LIQUID ROCKET BOOSTER (LRB)
KSC IMPACT

MAY 10, 1988

KSC LAUNCH RATE PROJECTIONS

BOOSTER VEHICLE	DATE	MLP's	VAB INTEG. CELLS	PADS	ORB	FLT RATE
RSRB	EARLY 90'S	2	2	1	3	10
ASRB	MID 90'S	3	2	2	4	16*
LRB	LATE 90'S	3	2	2	4	20*
LRB	2000+	4	3	2	4	24*

*ORBITER PROCESSING FORECAST STILL LIMIT ULTIMATE LAUNCH RATE TO 14 PER YEAR

LIQUID ROCKET BOOSTER (LRB)
KSC IMPACTS

MAY 10, 1988

LRB TRANSITION ISSUES/CONCERNS

- MIXED FLEET OPERATIONS (SRB AND LRB)
- MAJOR SEPARATE BOOSTER FACILITIES
  - LRB HORIZONTAL PROCESS FACILITY
  - MLP
  - PAD
- MAJOR SHARED FACILITIES
  - VAB INTEG CELLS
  - LCC (FIRING ROOMS)
- OPF AND ORBITER OPS UNCHANGED AND NOT IMPACTED
- MANPOWER REQUIREMENTS DURING TRANSITION
- FIRST-LINE FACILITY ACTIVATIONS NEED EARLY START FOR ASSURED 1996 FIRST LAUNCH
- SECOND-LINE FACILITY ACTIVATIONS TO BE PHASED TO SUPPORT STS MANIFEST/LRB LAUNCH RATE BUILDUP
- MINIMUM 5-YEAR TRANSITION TO FULL LAUNCH RATE CAPABILITY (14 PER YEAR
- ON-GOING SRB LAUNCH CAPABILITY = IMPORTANT BACKUP

LIQUID ROCKET BOOSTER (LRB) KSC IMPACTS

MAY 10, 1988

LRB TRANSITION ISSUES/CONCERNS (CONT'D)

- LRB RETRIEVAL, DISASSEMBLY, REFURBISHMENT REQUIRE DEFINITION
- LRB GROUND SOFTWARE (LPS) CHANGES REQUIRE DEFINITION
- THE PRIME CONCERN IS THE TRANSITION OF LRB AND ITS INTEGRATION WITH OTHER EMERGING PROGRAMS AT KSC (i.e., ASRM, ALS, SHUTTLE "C", ETC.)

VOLUME IV

SECTION 5

FIRST PROGRESS REVIEW

July 18, 1988

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KSC ADVANCED PROJECTS & TECHNOLOGY OFFICE

LIQUID ROCKET BOOSTER INTEGRATION FIRST PROGRESS REVIEW

JULY 1988

AGENDA

I. INTRODUCTION	GORDON ARTLEY
II. STUDY PROGRESS	
A) LRB PROJECT INTEGRATION	PAT SCOTT
B) BASELINE REQUIREMENTS	KEITH HUMPHRYES
C) IMPACT ANALYSIS	GREG DEBLASIO
D) PLANS, PRODUCTS AND MODEL	JERRY LEFEBVRE
III. SUMMARY	GORDON ARTLEY

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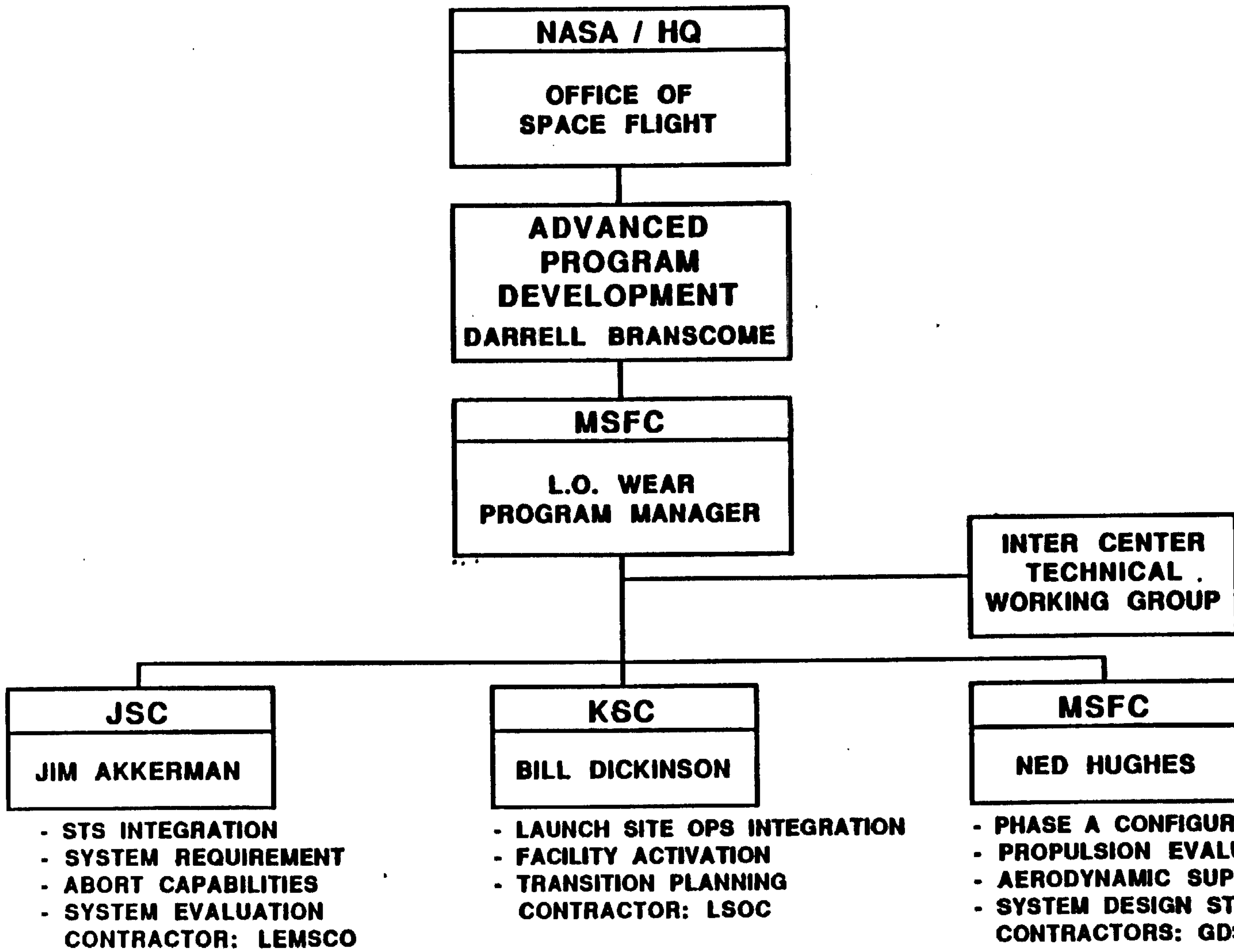
LRB STUDY TEAM MEMBERS

THE LRB STUDY TEAM IS COMPRISED OF EFFORTS AT THREE NASA CENTERS. THE LEMSCO STUDY AT JSC IS LED BY JIM MCCURRY AND DAVE BLUMENTRITT SUPPORTING JIM AKKERMAN IN THE LEVEL II INTEGRATION AND LRB SYSTEM PERFORMANCE EVALUATIONS. OUR TEAM AT LSOC IS LED BY GORDON ARTLEY AND REPORTS TO BILL DICKINSON FOR ALL THE LRB LAUNCH SITE INTEGRATIONS ISSUES. THE LRB PHASE A FLIGHT HARDWARE STUDIES AT MSFC ARE HEADED BY TOM MOBLEY AT MMC/MICHOND AND KEN NUSS AT GDSS. NED HUGHES, LRB CHIEF ENGINEER, COORDINATES THESE STUDIES, REPORTING TO LARRY WEAR, LRB PROGRAM MANAGER. THE TOTAL STUDY PROGRAM REPORTS THROUGH ADVANCED PROGRAM DEVELOPMENT UNDER DARRELL BRANSCOME TO THE OFFICE OF SPACE FLIGHT, NASA/HQ. THE INTERCENTER TECHNICAL WORKING GROUP MEETS EVERY TWO MONTHS ON MAJOR LRB ISSUES AT VARIOUS PRE-ARRANGED SITES.

LIQUID ROCKET BOOSTER INTEGRATION FIRST PROGRESS REVIEW

JULY 1988

LRB STUDY TEAM MEMBERS



STUDY OBJECTIVES

THE LIQUID ROCKET BOOSTERS WOULD PROVIDE ADDITIONAL PAYLOAD CAPACITY FOR THE SHUTTLE SYSTEMS AS WELL AS AN ON PAD HOLD-DOWN AN ENGINE CUT-OFF CAPABILITY PRIOR TO LAUNCH RELEASE TO ALLOW VERIFICATIONS OR PROPER SYSTEM PERFORMANCE. THE LRB SYSTEM MAY HAVE APPLICATIONS FOR FUTURE SPACE VEHICLES. KSC HAS, SEPARATE FROM LRB CONSIDERATIONS, DEVELOPED A GROUND OPERATIONS COST MODEL (GOCM) WHICH PROVIDES MACRO BUDGETARY ESTIMATES OF KSC GROUND OPERATION COSTS. THE GOCM IS CONSIDERED USEFUL IN THE CONDUCT OF EARLY CONFIGURATION TRADE STUDIES WHICH CONSIDER GROUND COST IMPACT BUT DOES NOT, IN ITS PRESENT CONFIGURATION, PROVIDE ADEQUATE RESOLUTION TO CONSIDER DETAIL DESIGN SENSITIVE COST DRIVERS.

LIQUID ROCKET BOOSTER INTEGRATION FIRST PROGRESS REVIEW

JULY 1988

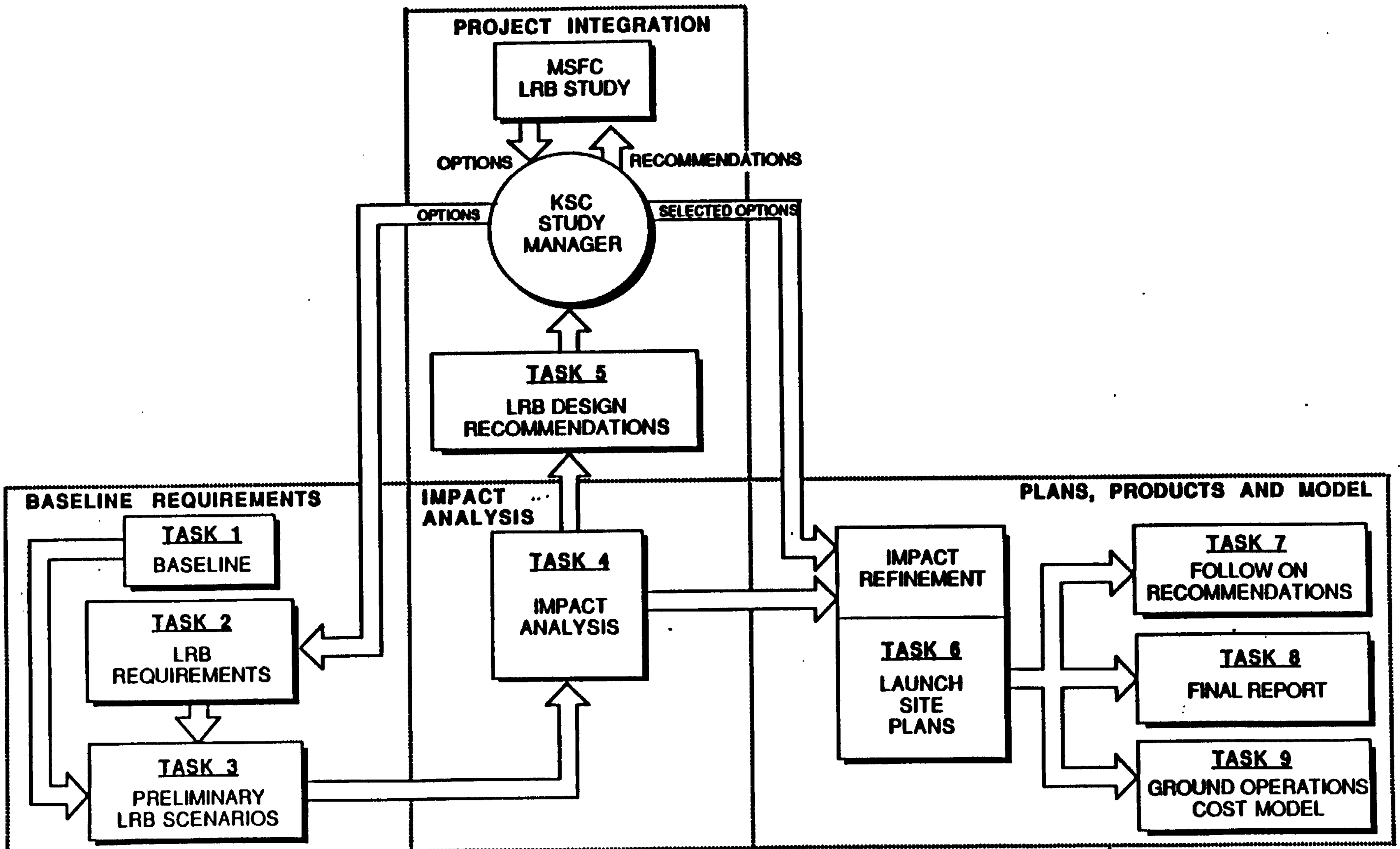
STUDY OBJECTIVES

1. DEVELOP LAUNCH SITE OPERATIONS AND FACILITY IMPACTS FOR MSFC-SELECTED LRB CONFIGURATIONS
2. DEVELOP PRELIMINARY OPERATIONAL SCENARIOS FOR SELECTED LRB CONFIGURATIONS
3. PROVIDE FLIGHT HARDWARE DESIGN RECOMMENDATIONS BASED ON OPERATIONAL CONSIDERATIONS
4. ASSIST IN THE DEVELOPMENT OF AN OPERATIONALLY EFFICIENT LRB SYSTEM
5. UTILIZE THE GROUND OPERATIONS COST MODEL (GOCM) IN THE PREPARATION OF LRB LAUNCH SITE COST ASSESSMENTS
6. DEVELOP PRELIMINARY LSE/GSE FOR LRB PROCESSING
7. DEVELOP LAUNCH SITE SUPPORT PLAN DEFINING MANPOWER REQUIREMENTS FOR LRB IMPLEMENTATION AND OPERATION

METHODOLOGY/STUDY TASKS

THE LRBI STUDY METHODOLOGY SHOWS THE MAJOR TASK FUNCTIONS AND THEIR INTERRELATIONSHIPS, AS WELL AS THE INTERFACE WITH THE MSFC PHASE A STUDY LEAD. THIS INTERFACE IS EXERCISED AT OUR TECHNICAL WORKING GROUP MEETINGS AND WITH THE LOCAL KSC REPRESENTATIVES. THIS INTERCHANGE HAS BEEN VERY PRODUCTIVE AND EFFECTIVE IN THE COMMUNICATION OF REQUIREMENTS AND DATA. OUR STUDIES TO DATE HAVE PROVIDED THE INITIAL INFLUENCE AND RECOMMENDATIONS TO THE MARSHALL INTEGRATION WORKING GROUP ORGANIZATIONS. WE HAVE PROGRESSED WELL INTO THE BASIC REQUIREMENTS. THIS INCLUDES THE ESTABLISHMENT OF THE CURRENT SHUTTLE/SRB BASELINE THROUGH THE YEAR 2006. THIS ALSO INCLUDES COMPILING THE LRB PROCESSING REQUIREMENTS AND SCENARIO. THE KSC IMPACT ANALYSIS TASKS HAVE FOCUSED ON CONCEPTUAL FACILITY TRADE STUDIES. THE PLANS AND MODEL EFFORTS HAVE FOCUSED ON THE ACCUMULATION OF REQUIRED DATA BASE, AND TO ESTABLISH FORMATS AND SOFTWARE CONCEPTS.

METHODOLOGY / STUDY TASKS



RAM

THE RESPONSIBILITY ASSIGNMENT MATRIX (RAM) DISPLAYED HERE RELATES THE NINE STUDY TASKS TO THE SIXTEEN STUDY PRODUCTS, SHOWING THE TASK AND TASK-LEAD FOR THE PRODUCTION OF EACH PRODUCT. THESE IDENTIFIED RESPONSIBILITIES ENABLE QUICK REFERENCE AND TRACKING OF THE STUDY EFFORT TOWARD MEETING THE EARLIER STATED OBJECTIVES.

LIQUID ROCKET BOOSTER INTEGRATION FIRST PROGRESS REVIEW

JULY, 1988

RAM

LRB RESPONSIBILITY ASSIGNMENT MATRIX RAM

REV B
DATE 6-7-88
SIGNATURE:

	STUDY PRODUCTS	1 BASELINE/SCOTT	2 REQUIREMENTS/ HUMPHRYES	3 SCENARIOS/SCOTT	4 IMPACTS/DEBLASIO	5 DESIGN RECOMMD/ ARTLEY	6 LAUNCH SITE PLAN/ HUMPHRYES	7 FOLLOW-ON RECOMMENDATIONS/ ARTLEY	8 FINAL REPORT/ HUMPHRYES	9 GROUND OPS COST MODEL/ PAPPAS	ASSIGNMENT
1	LRB GROUND OPS PLAN						X				HUMPHRYES
2	LRB TIMELINES			X							SCOTT
3	FACILITY REQMTS/CONCEPT				X						DEBLASIO
4	LAUNCH SUPPORT EQUIPMENT				X						DEBLASIO
5	GROUND SUPPORT EQUIPMENT				X						DEBLASIO
6	LRB MANPOWER						X				HUMPHRYES
7	COST ESTIMATES & TRANSITIONS						X				BURNS
8	IMPACTS TO ON-GOING ACTIVITIES			X							SCOTT
9	PRELIMINARY TRANSITION PLAN						X				HUMPHRYES
10	ENVIRONMENTAL/SAFETY ISSUES				X						LEE / CULBERTSON
11	PROPELLANT STORAGE/HANDLING				X						DEBLASIO
12	DESIGN REC/OPER EFFICIENCY					X					ARTLEY
13	GOCM USER MANUAL									X	SCHNEIDER
14	GOCM INSTRUCTIONS									X	PAPPAS
15	GOCM SOFTWARE									X	PAPPAS
16	FOLLOW-ON RECOMMENDATIONS							X			ARTLEY

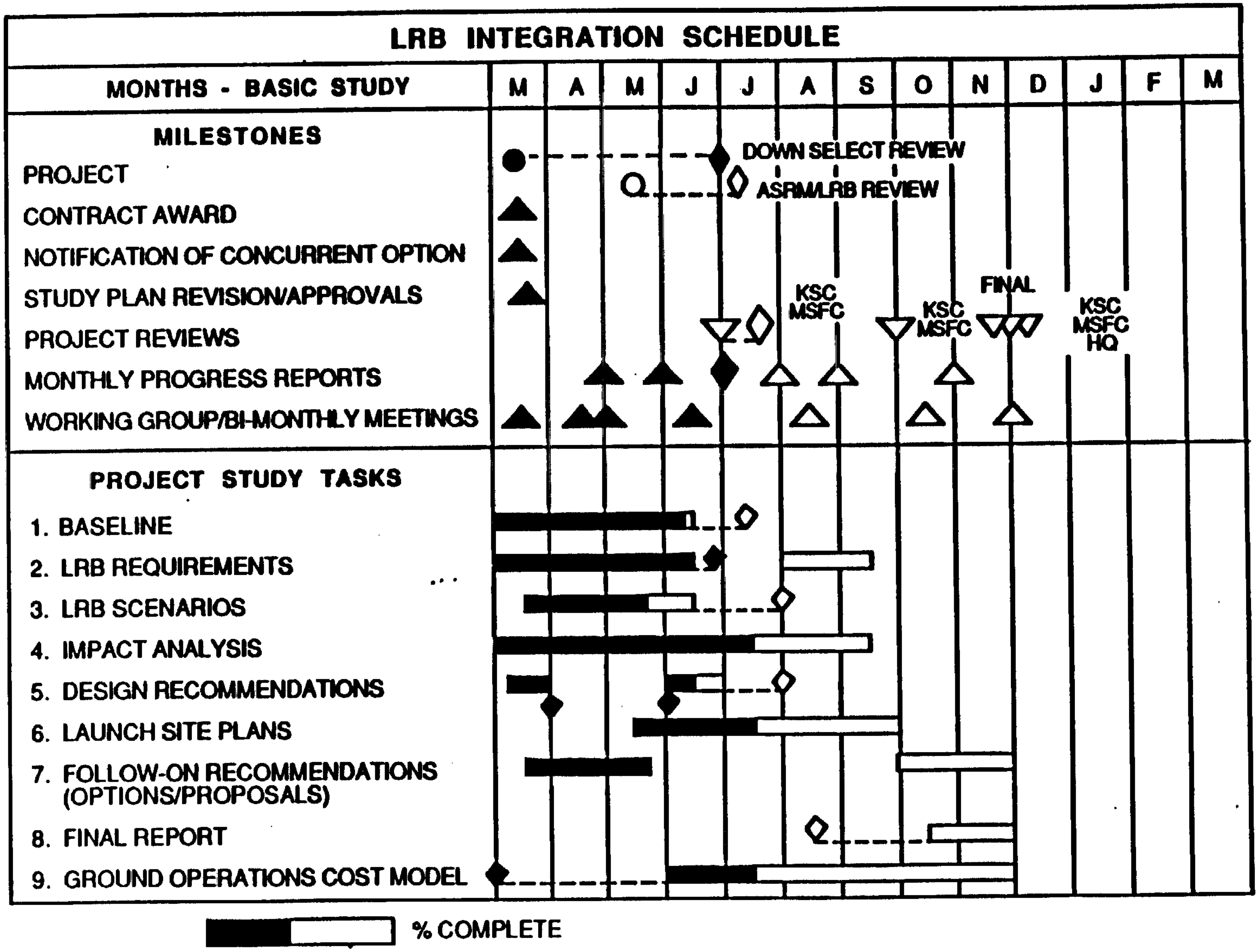
KSC LRB INTEGRATION SCHEDULE

THIS IS THE FIRST QUARTERLY REVIEW, BASED ON THE CONTRACT ATP IN MID-MARCH. INFORMAL COORDINATION WITH MSFC BEGAN IN OCTOBER. THE DOWN-SELECTED BOOSTER CONFIGURATIONS ON JUNE 29 & 30 HAVE PROVIDED A FRAMEWORK FOR THE FIRST FORMAL PRESENTATION TO KSC. SCHEDULE CHANGES HAVE BEEN MADE IN RESPONSE TO CHANGES IN STUDY EMPHASIS BY MSFC. PROGRESS, OPEN QUESTIONS AND PLANS FOR EACH OF THE FOUR TASK PACKAGES WILL BE DISCUSSED IN SECTION II OF THIS REVIEW.

KSC ADVANCED PROJECTS & TECHNOLOGY OFFICE

LIQUID ROCKET BOOSTER INTEGRATION FIRST PROGRESS REVIEW

JULY 1988



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KSC ADVANCED PROJECTS & TECHNOLOGY OFFICE

LIQUID ROCKET BOOSTER INTEGRATION FIRST PROGRESS REVIEW

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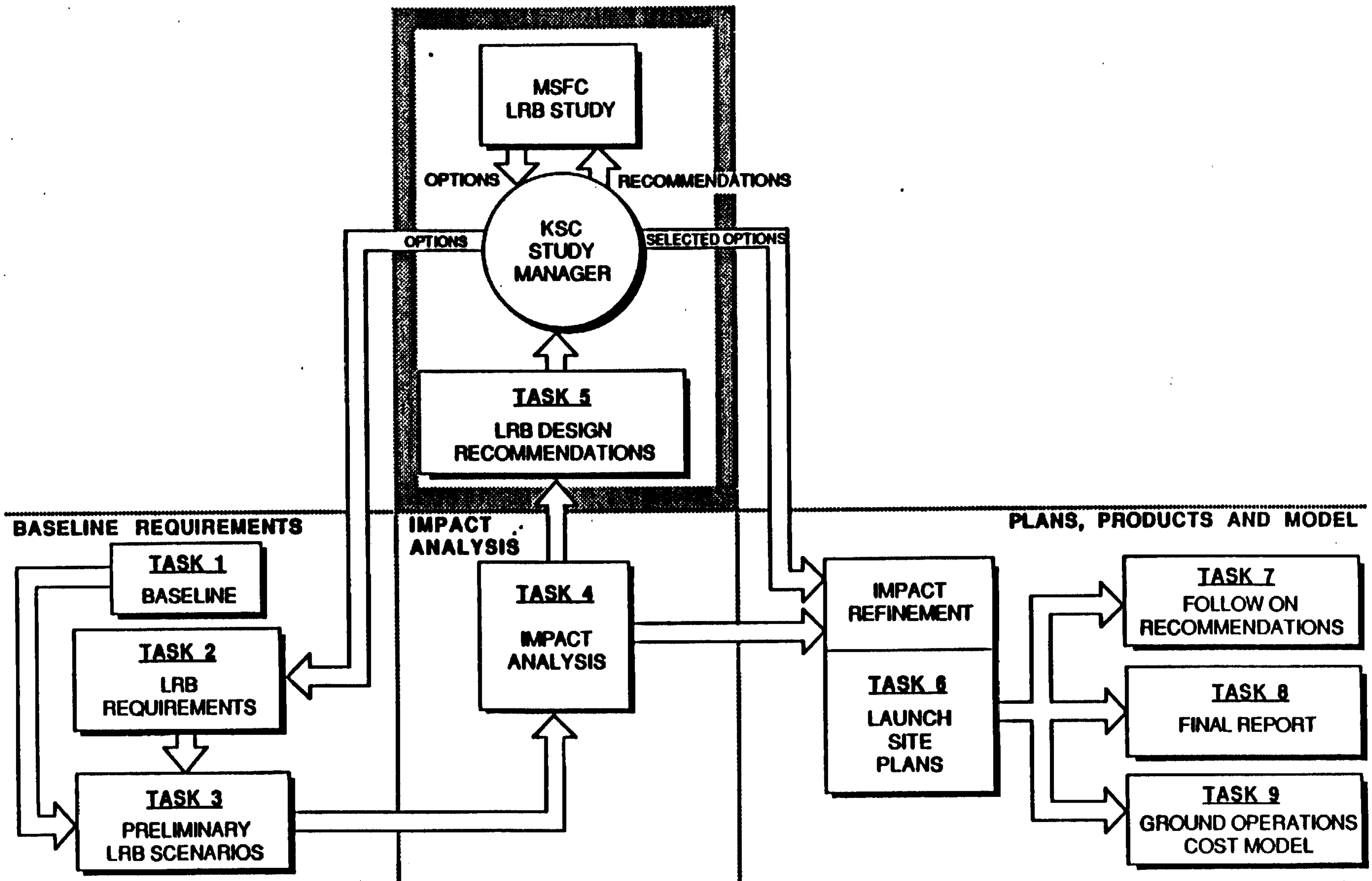
Lockheed Space Operations Company

LRB PROJECT INTEGRATION

JULY 1988



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PI-1A

LRB PROJECT INTEGRATION

- MSFC PHASE A CONFIGURATIONS
- LRB DESIGN RECOMMENDATIONS
- LRB PRELIMINARY PROCESSING SCENARIO
- FACILITY ACTIVATION / TRANSITION PLAN
- GENERIC FLOW / LAUNCH SITE COST ASSESSMENTS
- OPEN ISSUES / NEAR TERM PLANS

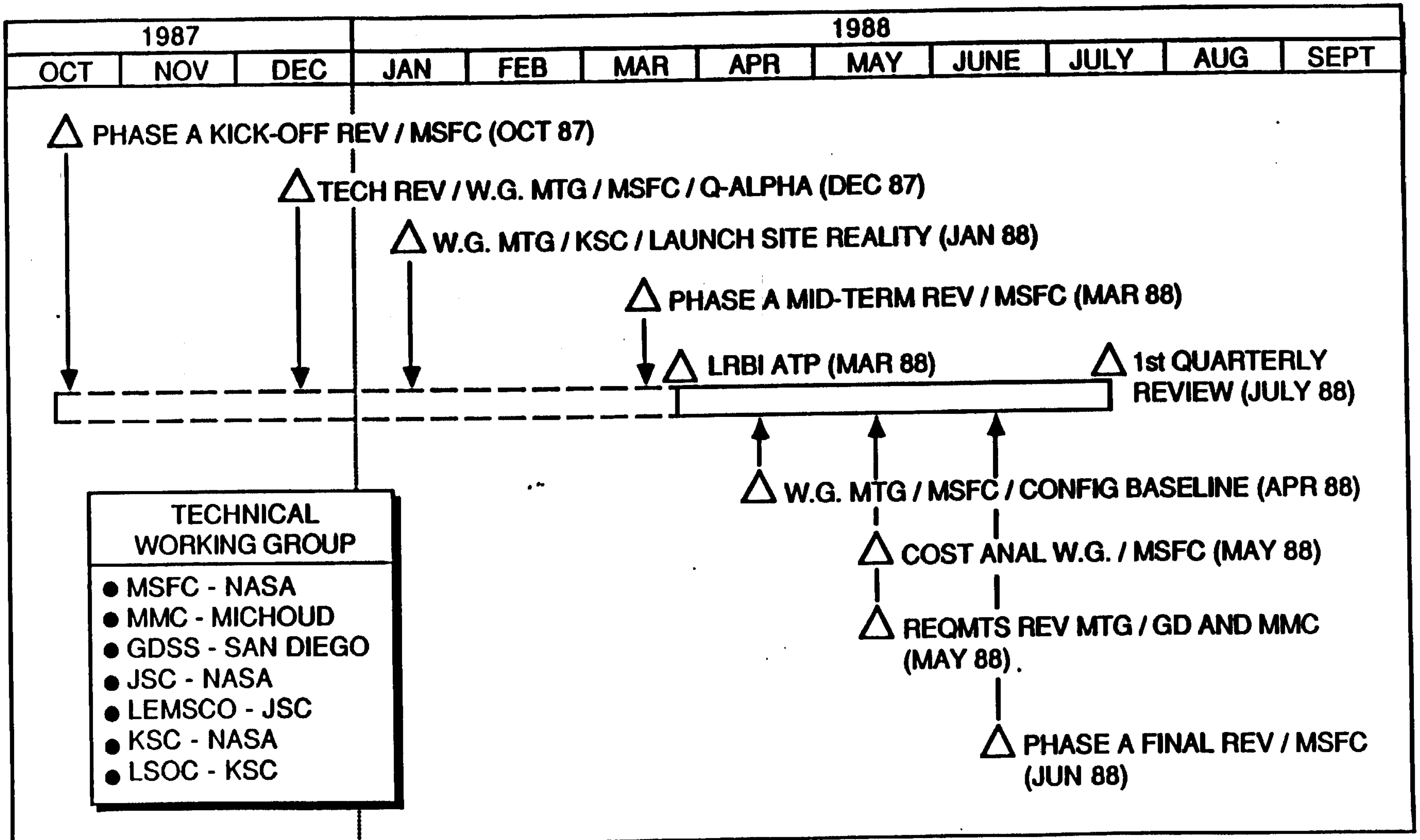
LRB PROJECT MILESTONES

MAJOR MILESTONES ARE IDENTIFIED HERE WITH REFERENCE TO OUR KSC STUDY. LRB PROJECT PARTICIPANTS ARE ORGANIZED INTO A THREE-CENTER TECHNICAL WORKING GROUP WHICH HAS PERIODICALLY CONVENED AND REVIEWED MAJOR PROJECT ISSUES. SUBJECTS SUCH AS VEHICLE AERODYNAMIC PROPERTIES, LAUNCH SITE INTEGRATION, PROJECT COST ANALYSIS AND PHASE A STUDY REVIEWS HAVE BEEN ADDRESSED. OUR STUDY TEAM AT KSC IS AN ACTIVE MEMBER OF THIS GROUP AND HOSTED THE JANUARY 88 KSC REVIEW. PREPARATION AND SUPPORT FOR THESE ACTIVITIES HAS REQUIRED A SIGNIFICANT AMOUNT OF OUR RESOURCES IN THE STUDY TO DATE. TECHNICAL INTERCHANGE WITH THE OTHER NASA CENTERS AND THEIR CONTRACTORS HAS BEEN VERY VALUABLE IN THE PERFORMANCE OF OUR LAUNCH SITE INTEGRATION PLANNING.

LIQUID ROCKET BOOSTER INTEGRATION FIRST PROGRESS REVIEW

JULY 1988

LRB PROJECT MILESTONES



MSFC PHASE A SELECTED CONFIGURATIONS

THE "DOWN-SELECTED" LRB CONFIGURATIONS FROM THE MSFC STUDIES ARE SUMMARIZED HERE. THERE ARE SIX IN ALL AND CONSIST OF THREE DIFFERENT PROPULSION CONCEPTS. BECAUSE OF THE SELECTION OF LOX/RP1 FOR BOTH PUMP FED AND PRESSURE FED VEHICLES, WE AT THE LAUNCH SITE HAVE CHOSEN THIS PROPELLANT FOR INITIAL IMPACT ANALYSIS. WHERE OTHER PROPELLANT OR VEHICLE DESIGN FEATURES CAUSE IMPACT AT THE LAUNCH SITE THOSE "DELTAS" WILL BE IDENTIFIED AND DOCUMENTED, BUT OUR "BASELINE" FOR ALL MAJOR TRADES IS THE <u>LOX/RP1 PUMP FED CONFIGURATION</u>. THE REUSABILITY ISSUE IS STILL IN EVALUATION AT KSC AND WILL CONTINUE CONCURRENT WITH THE MSFC PHASE B STUDY. CURRENTLY, BOTH CONTRACTORS AND MSFC HAVE SELECTED THE EXPENDABLE LRB CONCEPT.

MSFC PHASE A SELECTED CONFIGURATIONS

CONTRACTOR	PUMP FED	PRESS FED	SPLIT EXPANDER
GDSS	* LOX/RP1 LOX/LH2 (ALT)	LOX/RP1	LOX/CH4
MMC	* LOX/RP1	LOX/RP1	

* LAUNCH SITE BASELINE FOR INITIAL EVALUATIONS

NO FACING PAGE TEXT

CONFIGURATION DETAILS

- ALL SELECTED CONFIGURATIONS ARE 4-ENGINE, LOX TANK FORWARD, EXPENDABLE
- WEIGHT OF PRESS FED BOOSTERS EXCEED SRB LEVELS
- PRESS FED TEST BED PROGRAM HAS BEGUN AT MSFC WITH MMC & GDSS SUPPORT
- ALL BOOSTERS ARE DESIGNED TO EXISTING ORBITER / ET INTERFACES
- FLIGHT CONTROL VIA ELECTRO-MECH TVC / NO HYDRAULICS / NO HYDRAZINE

NO FACING PAGE TEXT

CONFIGURATION DETAILS (CONT)

- LIFT-OFF / IGNITION SEQUENCE STAGED FOR MIN BASE MOMENT / PROPELLANT OPTIMIZATION
- LIFT-OFF UMBILICALS / NO VENT ARMS EXCEPT H2 AND CH4 / HOLD DOWN SYSTEM IS MODIFIED POSTS CONCEPT
- ALUMINUM - LITHIUM TANK MATERIALS
- DESIGN BASED ON ATO WITH ONE LRB ENGINE OUT AT LIFT-OFF
- 70K PAYLOAD TO 150 NM 28.5° INCLINATION
- ALL SELECTED CONFIGURATIONS REQUIRE NEW LOW-COST ENGINE DEVELOPMENT - NO EXISTING ENGINE FOUND SUITABLE

GENERAL DYNAMICS
Space Systems Division

PROPERTIES OF SELECTED GDSS LRB CONCEPTS

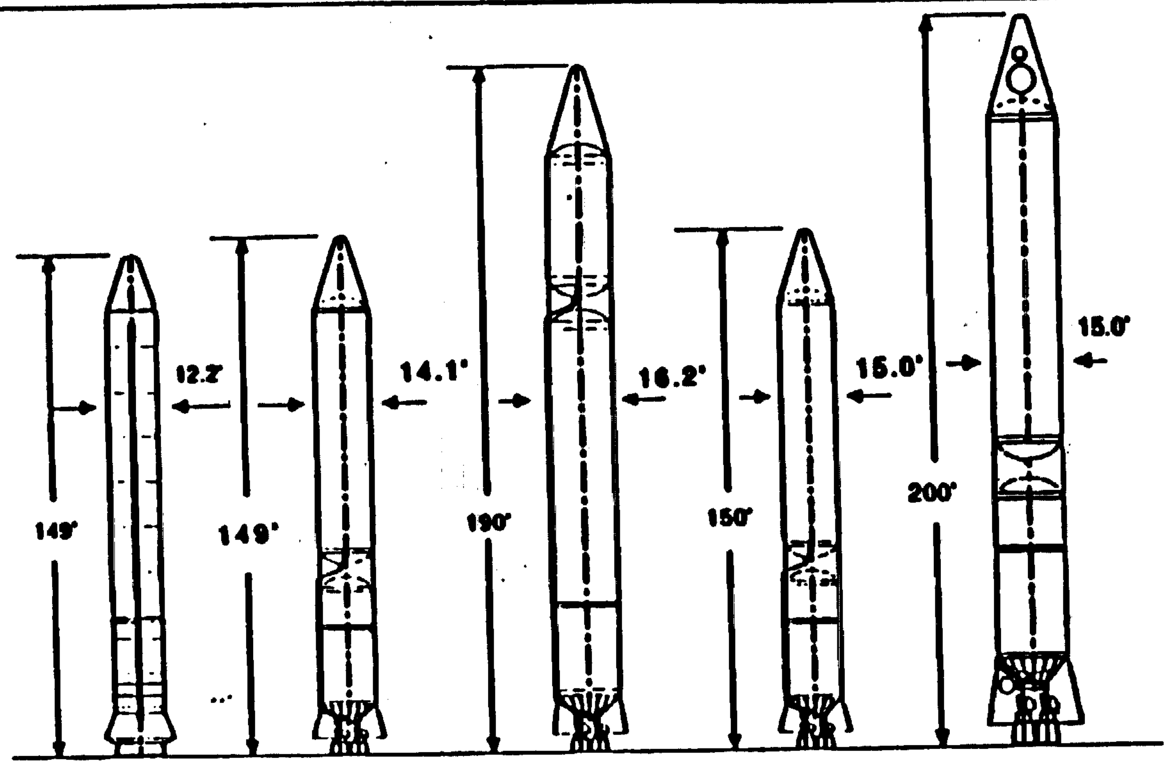
LRB	LO2/RP-1 PUMP	LO2/CH4 PUMP	LO2/LH2 PUMP	LO2/RP-1 PRESS FED
LENGTH (FT)	149.5	150.5	190.4	199.5
DIA (FT)	14.06	15.0	16.16	15.0
STRUCTURE	MONOCOQUE			
MATERIAL	AL-LI	AL-LI	AL - LI	AL 2219 - T6
PRESSURANT	AUTOG	AUTOG	AUTOG	TRIDYNE ($He/H_2/O_2$)
CHAMBER PRESS	1275 psia (NLP)	758 psia (RLP)	2366 psia (NLP)	334 psia (NLP)
ISP (VAC)	323	337	427	273
MIXTURE RATIO	2.53	3.5	6.0	2.5
EXIT DIA (IN)	108	106.9	108	108
FEED LINES (LOX)	SINGLE (24IN)	SINGLE (24IN)	SINGLE (24IN)	CONCENTRIC (24IN)

SELECTED LRB CONFIGURATIONS

GENERAL DYNAMICS
Space Systems Division

JUNE 1988

LRB



DATA (ONE BOOSTER)	SRB	LO2/RP-1 PUMP-FED	LO2/LH2 PUMP-FED	LO2/CH4 SPLIT-EXPANDER	LO2/RP-1 PRESSURE-FED
PROPELLANT (K lbs) DRY WEIGHT (K lbs)	1,117 146	957 114	645 120	906 104	1,492 228
THRUST (SL) (Klbs) Isp (Vac) (sec)	2,912 265	719 323	564 427	756 337	990 273
BLOW	1,250	1,015	736	960	1,633

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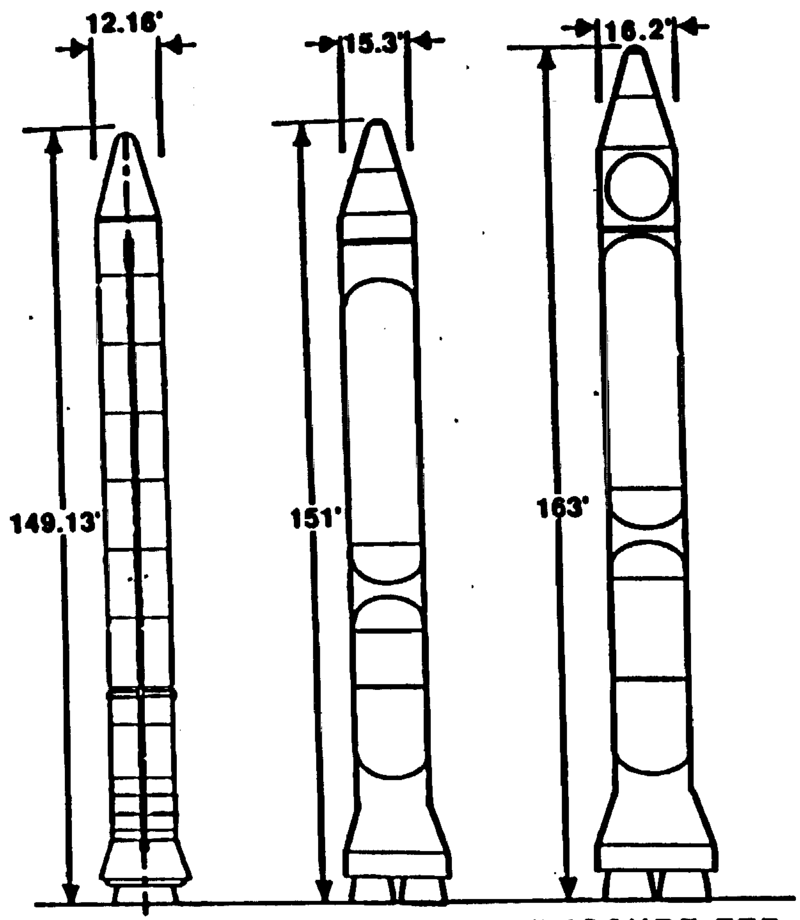
MMC - LRB VEHICLE CONFIGURATIONS

JULY 1988

• PROPERTIES	PUMP FED LOX/RP1	PRESS FED LOX/RP1
- OXID TANK VOLUME	10,769 FT3	12,012 FT3
- FUEL TANK VOLUME	5,796 FT3	6,328 FT3
- FEED LINES - LOX	17 IN. DUAL	25.5 IN. DUAL
- STRUCTURE	MONOCOQUE	MONOCOQUE
- MATERIAL	WELDALITE	WELDALITE
- INERT WEIGHT	116,665 LB	199,520 LB
- TOTAL WEIGHT (BLOW)	1,092,000 LB	1,300,860 LB
- PRESSURANT	AUTOGENOUS	SC He/10°R, (3000 psi)
- PRESSURANT VOLUME	-	1,000 FT3
- MIXTURE RATIO	2.5:1	2.67:1
- CHAMBER PRESS (PSI)	1300 EPL	800 FPL
- THRUST S.L. (EA.)	655 KLB	750 KLB
- ISP (VAC)	322 SEC	320 SEC

LIQUID ROCKET BOOSTER INTEBRATION FIRST PROGRESS REVIEW

MMC - LRB VEHICLE CONFIGURATIONS



KSC LRB DESIGN RECOMMENDATIONS

DURING THE COURSE OF OUR STUDY WE HAVE SUPPORTED THE ORGANIZATION OF A LAUNCH SITE WORKING GROUP MEETING AT KSC IN JANUARY 88, TWO WORKING GROUP MEETINGS AT MSFC (ONE ON COSTS, ONE ON AERO LOADS) AND VISITS TO MMC, MICHOUD AND GDSS - SAN DIEGO ON THE SUBJECT OF BOOSTER PROCESSING REQUIREMENTS. AT EACH OF THESE INTERFACE MEETINGS WE TOOK THE OPPORTUNITY TO IDENTIFY LRB DESIGN RECOMMENDATIONS THAT WOULD ENHANCE LAUNCH SITE OPERATIONS. SHOWN HERE ARE SOME OF THE MORE SIGNIFICANT FLIGHT VEHICLE DESIGN ISSUES IDENTIFIED. SOME (BUT NOT ALL) HAVE BEEN INCORPORATED INTO THE SELECTED LRB CONFIGURATIONS.

KSC-LRB DESIGN RECOMMENDATIONS:

✓ INDICATES INCORPORATED DESIGN FEATURE

- NO HYDRAULICS/NO HYDRAZINE ✓
- USE LIFT-OFF UMBILICALS - NO SWING ARMS OR LUT ✓
- MAXIMUM LRB DIAMETER LESS THAN 16 FEET
- LOCATE AVIONICS LRUs IN AFT SKIRT AREA ✓
- FACILITATE ENGINE R/R IN VERTICAL ON MLP ✓
- USE EXPENDABLE DESIGN ✓
- LOX/RP-1 PROPELLANTS HAVE MINIMUM PAD IMPACTS ✓
- NO FLAME TRENCH (CONCRETE) MODS AT PAD ✓
- FACILITATE VERTICAL AND HORIZONTAL CHECKOUT ✓
- MAKE BOOSTER AUTONOMOUS WITH MINIMUM ORBITER INTERFACES

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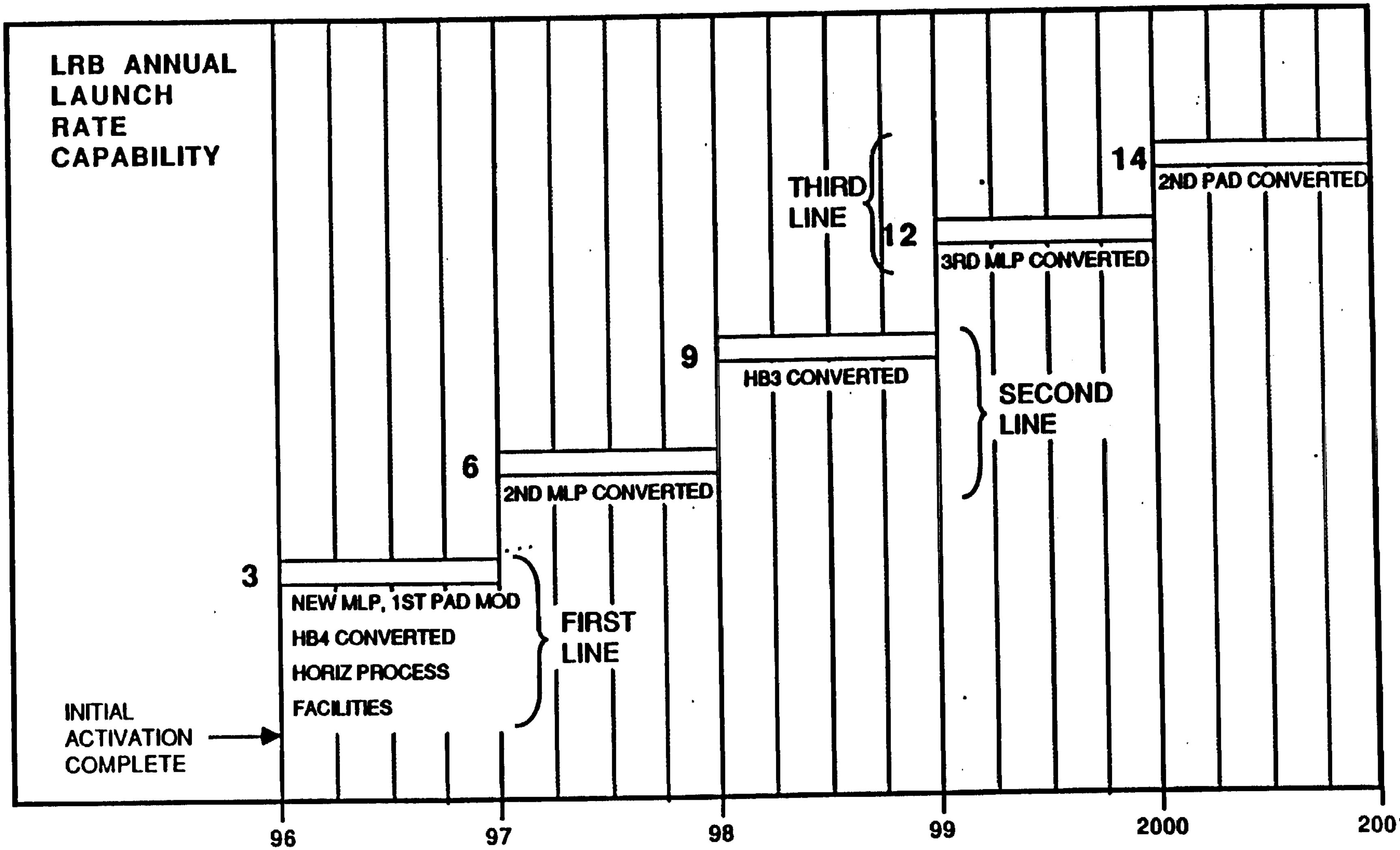
KSC-LRB DESIGN RECOMMENDATIONS (CONT) :

- USE SEPARATE BOOSTER DOWNLINK (RF)
- FACILITATE SEPARATE LRB STAND ALONE TEST AND CHECKOUT ✓
- ON BOARD LOX VENTS / NO BEANIE CAP ✓
- HARD MOUNTED ENGINES (NOZZLE GIMBALS FOR TVC)
- MINIMIZE ET MODS ✓
- ELIMINATE ENGINE PURGES, BLEEDS AND SPECIAL PREPS
- CONSIDER EXTERNAL POD FOR AVIONICS AND BATTERIES TO FACILITATE ACCESS AND EASE OF SERVICE
- AVOID ELEPHANT TRUNKS (TRAPS) IN PROPELLANT LINES THAT REQUIRE SPECIAL ATTENTION ✓

LRB ANNUAL LAUNCH RATE CAPABILITY

THE ANNUAL LRB/SRB LAUNCH RATE CAPABILITY DURING THE 5-YEAR TRANSITION OF LRB IS PLANNED TO SUPPORT A CONTINUING 14 LAUNCHES PER YEAR STS MANIFEST. INCREMENTAL FACILITY ACTIVATIONS FOR LRB ARE PLANNED AFTER IOC TO SUPPORT THE PLANNED LRB LAUNCH RATE BUILD-UP. SRB SUPPORTED LAUNCHES WILL DECLINE ACCORDINGLY DURING THIS PERIOD.

AT KSC THE PLANNED IOC (FIRST LINE) FACILITY ACTIVATIONS ARE SCHEDULED OVER THE 1991 TO 1996 TIME FRAME LEADING UP TO THE "INITIAL ACTIVATION COMPLETE" POINT.



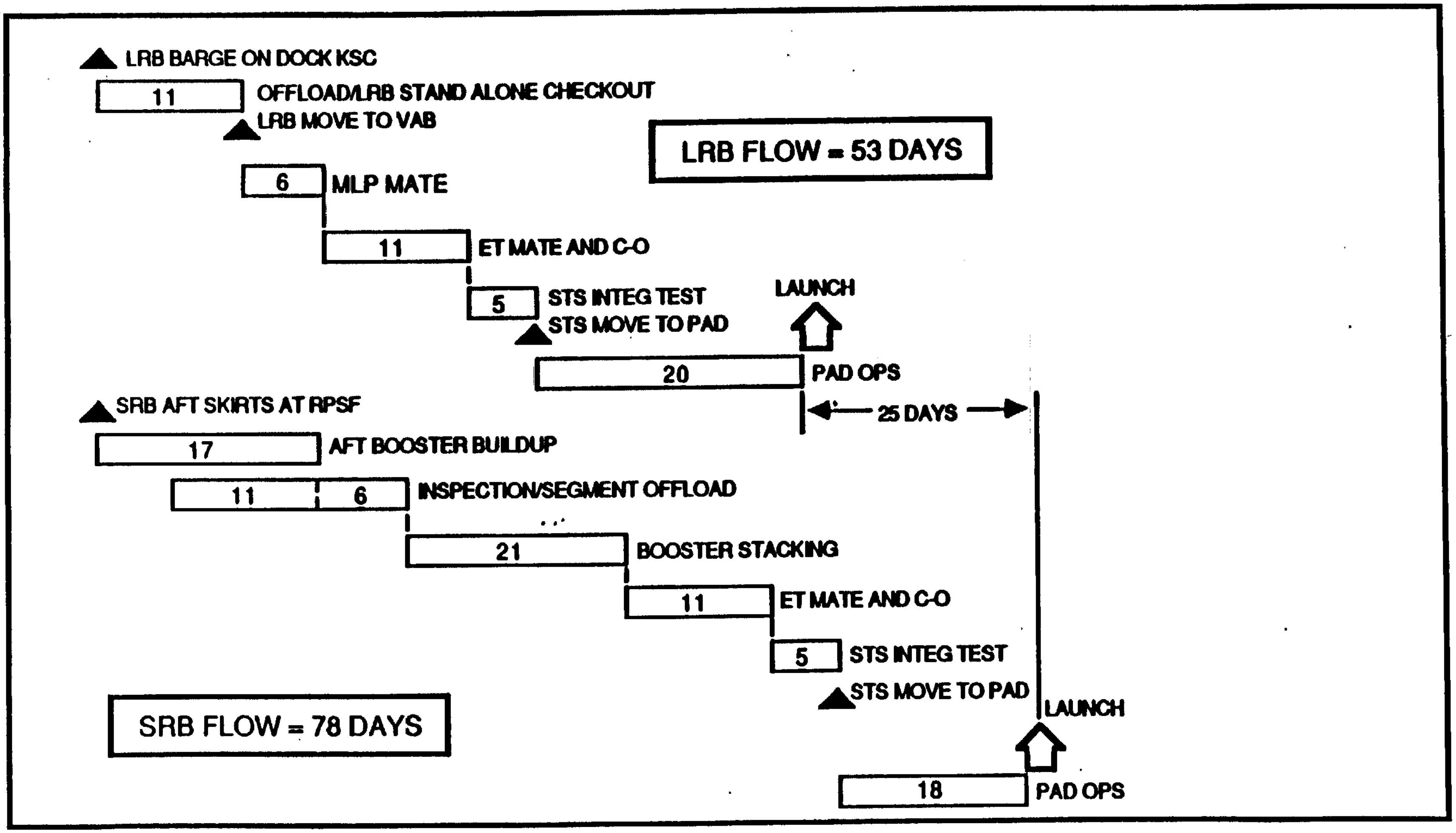
FACILITY ACTIVATION / TRANSITION PLAN

GENERIC LRB/SRB PROCESS FLOW COMPARISON

TYPICAL TIMELINES FOR STS PROCESSING ARE COMPARED TO SHOW THAT LRB PLANNED FLOW TIME FROM RECEIPT TO LAUNCH IS 25 DAYS SHORTER THAN THE MID-90'S PROJECTION FOR SRB/ASRM. THIS RESULTS IN INCREASED LAUNCH RATE CAPABILITY FOR THE LIQUID-BOOSTED STS AFTER FULL TRANSITION.. DIFFERENCES ARE DUE MAINLY TO THE SHORTENED BUILD-UP AND STACKING TIMES REQUIRED BY LRB.

A DETAILED LRB PROCESS FLOW FROM BARGE DELIVERY THROUGH LAUNCH HAS BEEN DEVELOPED. IT IDENTIFIES OVER 100 TASKS WITH SEQUENCE, MANPOWER AND SHIFT DURATIONS. THIS MODEL HAS BEEN NETWORKED IN ARTEMIS AND WILL BE USED IN OUR CONTINUING ANALYSIS EFFORTS TO ASSESS OPERATIONAL EFFICIENCY, MULTIFLOW INTEGRATION, AND FACILITY UTILIZATION.

GENERIC LRB/SRB PROCESS FLOW COMPARISON



NOTE: SRB RETRIEVAL, DISASSEMBLY, REFURBISHMENT AND REMANUFACTURING ARE NOT SHOWN.

KSC LAUNCH RATE PROJECTIONS

KSC LAUNCH RATE PROJECTIONS VS. FACILITIES ARE SUMMARIZED HERE FOR KNOWN BOOSTER CONFIGURATIONS (RSRB, ASRB, AND LRB). CURRENT FORECASTS FOR ORBITER PROCESSING TIMES OF 51 DAYS IN THE OPF LIMIT EFFECTIVE LAUNCH RATES, HOWEVER THE BOOSTER AND INTEGRATED VEHICLE CAPABILITIES ENABLE ANNUAL RATES UP TO 24 PER YEAR BY THE YEAR 2000. CURRENT PLANNED LRB FACILITY ACTIVATIONS THRU TRANSITION SUPPORT THE 20 PER YEAR CAPABILITY.

THESE RESULTS ARE PRELIMINARY FORECASTS; MORE DETAILED MULTIFLOW ARTEMIS ANALYSIS WITH OUR REFINED LRB FLOW MODELS WILL BE PERFORMED TO ESTABLISH MORE ACCURATE FLIGHT RATE CAPABILITIES.

KSC LAUNCH RATE PROJECTIONS

BOOSTER VEHICLE	DATE	MLP's	VAB INTEG. CELLS	PADS	ORB	FLT RATE
RSRB	EARLY 90'S	2	2	1	3	10
ASRB	MID 90'S	3	2**	2	4	14*
LRB	LATE 90'S	3	2	2	4	20*
LRB	2000+	4	3	2	4	24*

* ORBITER PROCESSING FORECAST STILL LIMIT ULTIMATE LAUNCH RATE TO 14 PER YEAR (ASSUMING 4-ORBITER FLEET, 3 OPFs AND 51-DAY FLOWS)

** VAB HB3 & HB1 UTILIZATION IS NEAR 100% AT A LAUNCH RATE OF 14 PER YEAR USING A 21-DAY STACK TIME

KSC LIFE CYCLE COSTS FOR LRB

A PRELIMINARY LRB LAUNCH SITE COST ASSESSMENT WAS PERFORMED TO SCOPE THE MAJOR COST ITEMS AND TO SUPPORT THE MAY 10 COSTING REVIEW AT MSFC. SUMMARIZED HERE ARE THE MAJOR COST ELEMENTS COMPRISING BOTH NON-RECURRING AND RECURRING COSTS AT KSC. ELEMENTS ARE FACTORED BY 40% FOR COMPARISON WITH THE OTHER PROGRAM INPUTS: (CONTRACTOR FEE=10%, GOVT. SUPPORT=5%, MGMT. RESERVE=25%). COSTS ARE IN CONSTANT FY 87 DOLLARS AND REPRESENT TOTAL LIFE CYCLE INCLUDING A FIVE-YEAR ACTIVATION PHASE AND A TEN-YEAR OPERATIONAL PHASE.

OUR GROUND OPERATIONS COST MODEL (GOCM) DEVELOPMENT WILL RESULT IN A MORE FLEXIBLE COST MODELING APPROACH AND THE ABILITY TO EVALUATE AND CORRELATE PROGRAM COST APPROACHES SUCH AS THIS ASSESSMENT. DETAILED COST ELEMENTS SUPPORTING THIS SUMMARY ARE AVAILABLE FOR REVIEW.

LIQUID ROCKET BOOSTER INTEGRATION FIRST PROGRESS REVIEW

JULY 1988

KSC LIFE CYCLE COSTS FOR LRB

COST ELEMENT	UNIT COST	TIME SPAN	TOTAL	TOTAL W/40%
NON-RECURRING				
1. FIRST-LINE FACILITY	$ 205M	91-95	$ 205M	$287M
2. SECOND/THIRD-LINE FAC.	173M	96-00	173M	242M
3. GSE/LSE	98.5M	91-95	98.5M	138M
4. GROUND S/W - LPS	20M	91-95	20M	28M
5. ORBITER/ET MODS	TBD	--	TBD	TBD
			$496.5M	$ 695M
RECURRING				
6. BOOSTER PROC. MANPOWER	$3.34M /FLOW (X 120 FLTS)	96-06	400.8M	$ 561M
7. OPERATIONS SUPPORT MANPOWER	(INCLUDED IN ABOVE)			
8. ON-GOING LRB MODIFICATIONS	TBD	—	—	TBD

LCC GRAND TOTAL = $1256M*

*TOTAL LCC COST DOES NOT INCLUDE RECOVERY, DISASSEMBLY OR REFURBISHMENT COST ELEMENTS. ALSO DOES NOT INCLUDE RECYCLE/RECERT COSTS AT THE LAUNCH SITE.

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LIQUID ROCKET BOOSTER INTEGRATION FIRST PROGRESS REVIEW

JULY 1988

OPEN ISSUES:

1. RECOVERY / DISASSEMBLY= OPTION

2. SRB - TO - LRB TRANSITION PLANNING
   - FACILITY / GSE MODS AND ACTIVATION
   - GROUND SOFTWARE MODS / NEW LRB SOFTWARE
   - OMI DEVELOPMENT / TEST TEAM TRAINING

3. LAUNCH SITE VERIFICATION / VALIDATION

4. MIXED FLEET INTEGRATION / SHARED FACILITIES

5. COST ASSESSMENT REFINEMENTS / ANALYSIS

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NEAR TERM PLANS:

1. CONTINUE MSFC / JSC AND CONTRACTOR COORDINATION FUNCTIONS
2. SUPPORT FOLLOW-UP TECHNICAL WORKING GROUP MEETINGS WITH MMC AND GDSS AFTER REVIEW OF PHASE A FINAL REPORTS (DUE MID-JULY)
3. COORDINATE LRB LAUNCH SITE PROCESSING SCENARIOS AND IDENTIFY ALL MAJOR DELTAS FOR EACH SELECTED CONFIGURATION
4. REFINE LAUNCH SITE COST ASSESSMENTS PER CONTRACTOR REQUIREMENTS AND CORRELATE WITH THE GROUND OPERATIONS COST MODEL (GOCM)

KSC ADVANCED PROJECTS & TECHNOLOGY OFFICE

LIQUID ROCKET BOOSTER INTEGRATION FIRST PROGRESS REVIEW

JULY 1988

AGENDA

I. INTRODUCTION	GORDON ARTLEY
II. STUDY PROGRESS	
A) LRB PROJECT INTEGRATION	PAT SCOTT
B) BASELINE REQUIREMENTS	KEITH HUMPHRYES
C) IMPACT ANALYSIS	GREG DEBLASIO
D) PLANS, PRODUCTS AND MODEL	JERRY LEFEBVRE
III. SUMMARY	GORDON ARTLEY

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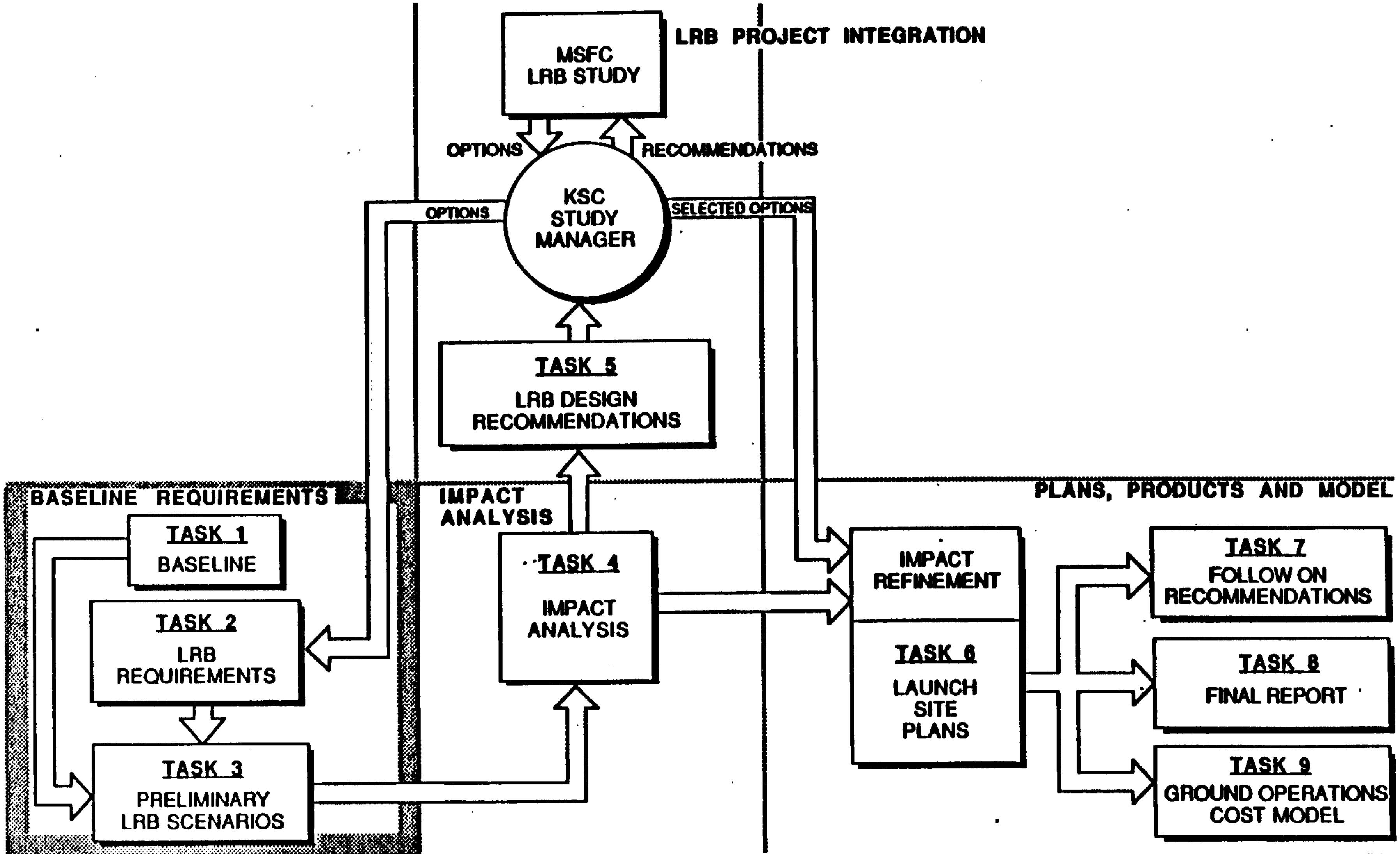
BASELINE REQUIREMENTS

JULY 1988



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TASK 1 - SRB BASELINE DEFINITION

THE OBJECTIVE OF DEFINING THE SRB BASELINE IS TO PROVIDE A BASIS OF COMPARISON FOR LRB WITH PARAMETERS OF MANPOWER, COST, SCHEDULE AND SAFETY/ENVIRONMENTAL.

USING HISTORICAL DATA FROM PREVIOUS STS PROCESSING WE HAVE COMPILED A BASELINE FOR THE RSRB PROCESSING THROUGH 2006. THIS BASELINE REFLECTS THE CHANGES MADE IN REQUIREMENTS AND PROCEDURES AFTER 51L WITH AN APPROPRIATE LEARNING CURVE. WE HAVE INCLUDED PROCESSING SCHEDULES, MANPOWER AND COST WHICH IS TO BE USED FOR COMPARISON WITH THE LRB AND FOR TRANSITION PLANNING. WHILE BASED ON ACTUAL DATA THESE PARAMETERS ARE ESTIMATES WITH SOME DEGREE OF UNCERTAINTY DUE TO OUR LACK OF EXPERIENCE WITH THE NEW (PRESENT) REQUIREMENTS AND PROCEDURES.

TASK 1 - SRB BASELINE DEFINITION

- BASELINE SRB PROCESSING
- SCHEDULE
- SRB PROCESSING MANHOURS AND COST

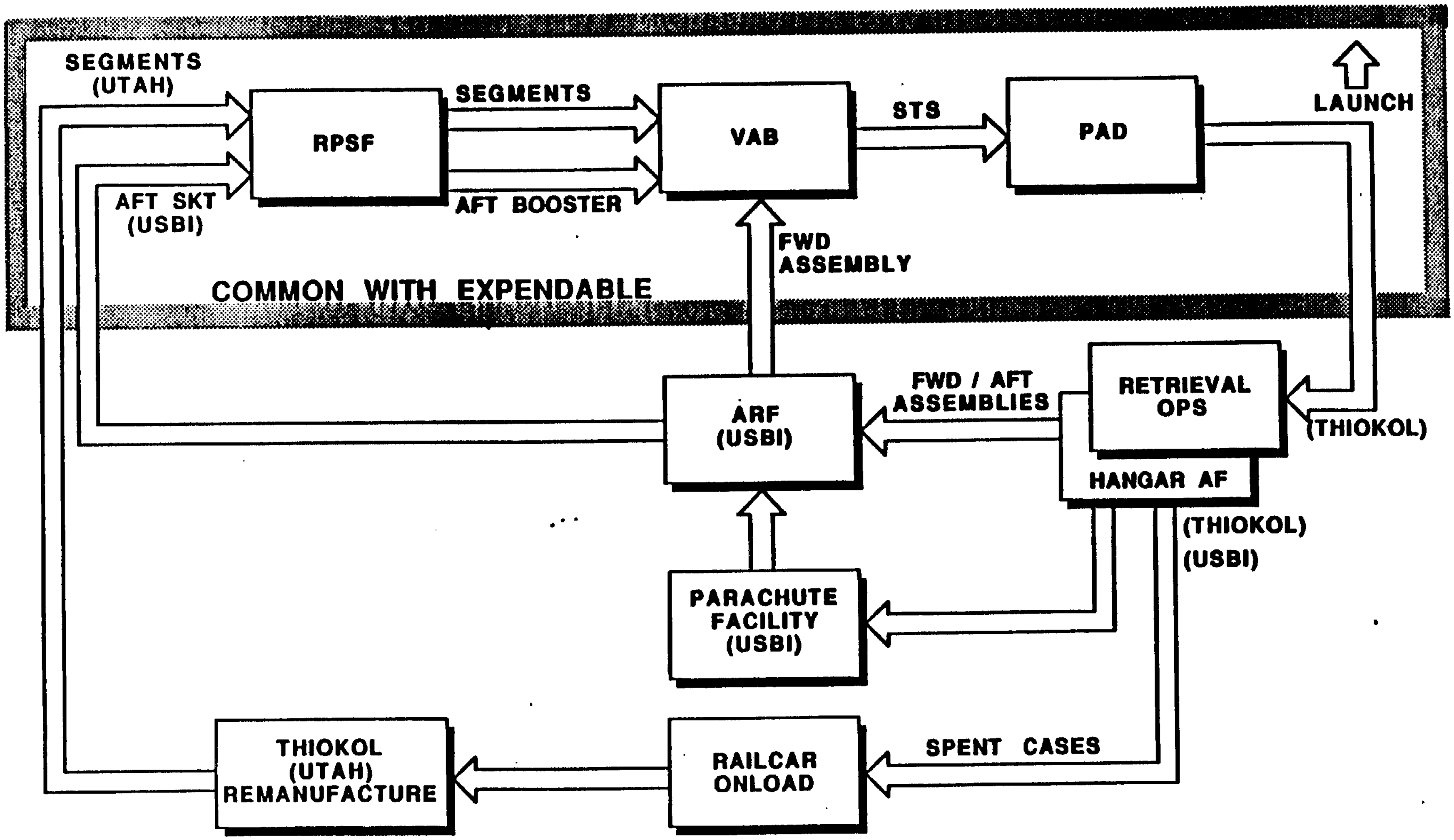
BASELINE SRB PROCESSING

THE SHADED LINES ENCLOSE THE PORTION OF THE SRB PROCESSING FLOW WHICH IS COMPARABLE TO AN EXPENDABLE LRB. THE RESOURCES, FACILITIES AND COSTS ASSOCIATED WITH THIS PORTION OF THE SRB PROCESSING ARE USED AS A BASELINE OF COMPARISON. THE PORTION OUTSIDE THE SHADED LINES CAN BE AGGREGATED WITH OTHER ELEMENTS OF LIFE CYCLE COST TO MAKE PROGRAMMATIC TRADES WITH LRB MANUFACTURING.

LIQUID ROCKET BOOSTER INTEGRATION
FIRST PROGRESS REVIEW

JULY 1988

BASELINE SRB PROCESSING



SCHEDULE

THE BARS REFLECT THE CURRENT ELAPSED TIME (DAYS) PROJECTIONS FOR SRB PROCESSING IN THE 1996 TIME FRAME. POST 51L PROCESSING CHANGES HAVE BEEN INCORPORATED WITH A LEARNING CURVE. THE BARS ARE NOMINAL, SUCCESS-ORIENTED TIMES. THE INSPECTION/OFFLOAD BAR IS SEGMENTED TO SHOW THE SIX DAY SERIAL TIME SPAN. PAD OPERATIONS INCLUDES THREE DAYS FOR VERTICAL PAYLOAD INTEGRATION.

LIQUID ROCKET BOOSTER INTEGRATION FIRST PROGRESS REVIEW

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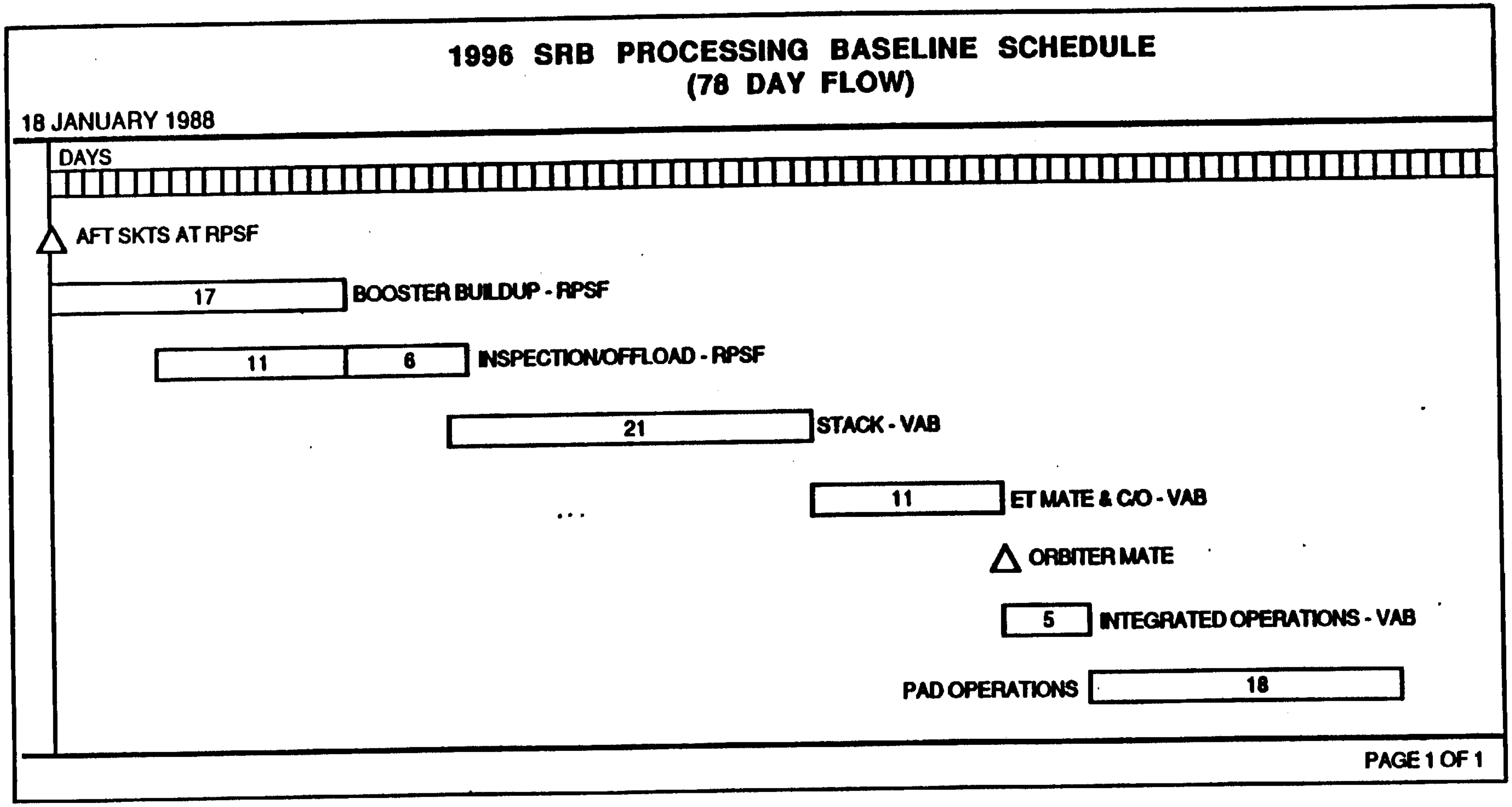
TASK 1 - SRB BASELINE DEFINITION



SRB PROCESSING MANHOURS AND COST

IN DEFINING BASELINE COST AND MANHOURS FOR SRB WE ARE PRIMARILY INTERESTED IN THE PRE-LAUNCH, GROUND PROCESSING FOR COMPARISON WITH LRB. OTHER SUPPORT SUCH AS BASE OPERATIONS IS ASSUMED TO BE THE SAME FOR ANY FLIGHT CONFIGURATION AND IS, THEREFORE, NOT PRESENTED.

THE COST AND MANHOUR DATA ARE BASED ON SPC ACTUALS FROM PREVIOUS MISSIONS. SPC COST AND MANHOUR DATA ARE PWO AND WBS DATA. LSOC SUPPORT IS ENGINEERING EXCEPT "PAD PROCESSING" HALF OF WHICH IS TECHNICIANS AND "OPS SUPPORT" WHICH IS QUALITY. THE PRESENTED NUMBERS ARE STATISTICALLY DERIVED. THEY ARE THE UPPER LIMITS OF THREE STANDARD DEVIATIONS AND THEREFORE REPRESENT A 95 % PROBABILITY THAT THE COSTS WILL NOT BE HIGHER. THIS IS BELIEVED TO BE A CONSERVATIVE APPROACH, IN THAT ALLOWANCES FOR POST 51L REQUIREMENT INCREASES HAVE NOT BEEN MADE AND THEIR EFFECTS ARE NOT YET CLEARLY QUANTIFIED.

TASK 1 - SRB BASELINE DEFINITION

SRB PROCESSING MHRS AND COST (PER FLIGHT)

SRB ACTIVITY	MANHOURS	COST
SRB PROCESSING	18,603	$ 311,191
SRB STACKING	10,240	181,008
VAB INTEGRATION	5,095	88,728
PAD PROCESSING	18,575	343,842
SRB SHOPS/SE MAINT	3,378	54,264
SRB OPS SUPPORT	6,898	179,466
INTEG OPS SUPPORT	7,961	164,167
PSF - MAINT	2,818	54,488
VAB - MAINT	4,639	90,196
PAD/MLP - MAINT	276	5,661
SAFETY	5,377	114,630
OVERHEAD	4,183	90,407
SPC (LSOC) SUPPORT		
SRB PROCESSING	1,120	23,016
SRB STACKING	784	16,111
VAB INTEGRATION	254	5,220
PAD PROCESSING	5,704	109,146
OPS SUPPORT	814	14,888
GRUMMAN	3,997	78,936
	100,716	$1,925,365

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TASK 1 - SRB BASELINE DEFINITION

- OPEN QUESTIONS AND ISSUES - NONE
- WORK PLAN FOR NEXT PERIOD

  FINALIZE DATA AND FORMAT FOR
  FINAL REPORT

TASK 2 - LRB REQUIREMENTS

THE OBJECTIVE OF THIS TASK IS TO DEFINE ALL THE SIGNIFICANT LRB REQUIREMENTS AS THEY APPLY TO LAUNCH SITE PROCESSING. THESE REQUIREMENTS ARE THOSE THAT ARE LEVIED UPON THE LAUNCH SITE BY VIRTUE OF THE LRB DESIGN/CONFIGURATION AND THOSE THAT KSC WOULD REQUIRE OF THE MANUFACTURER(S). THESE REQUIREMENTS ARE BEING DEFINED/DEVELOPED THROUGH CLOSE COORDINATION WITH THE KSC STUDY MANAGER, MSFC, JSC AND THE PHASE A CONTRACTORS. THE DATA WAS ASSEMBLED FROM RESPONSES TO OUR REQUIREMENTS CHECKLIST, LRB TECHNICAL WORKING GROUP PRODUCTS AND VARIOUS RELATED DOCUMENTS.

TASK 2 - LRB REQUIREMENTS

- REQUIREMENTS DEFINITION
- KSC REQUIREMENTS

REQUIREMENTS DEFINITION

A REQUIREMENTS CHECKLIST WAS PRODUCED AND SUBMITTED TO THE PHASE A CONTRACTORS. FOR SPECIFIC INFORMATION ABOUT EACH PROPOSED LRB CONFIGURATION. IT INCLUDES PHYSICAL PROPERTIES, GENERAL REQUIREMENTS AND SPECIFIC REQUIREMENTS WITH RESPECT TO THE TEN AREAS OF IMPACT * AS DEFINED IN THE STUDY PLAN. ALL OF THE PERTINENT ISSUES, SUCH AS HORIZONTAL VS. VERTICAL PROCESSING AND STAND ALONE TESTING, ARE COVERED. PRIOR TO RECEIVING THESE DATA, THE STUDY TEAM DEVELOPED A LOX/RP1 GENERIC BASELINE FOR A PUMP AND A PRESSURE FED CONFIGURAITON. THIS ALLOWED US TO PROCEED WITH VARIOUS STUDY ELEMENTS WHICH WERE DEPENDENT UPON CONFIGURATION DATA. WE ATTENDED ALL OF THE VARIOUS WORKING LRB SESSIONS AND VISITED THE PLANTS OF GDSS MMC TO OBTAIN DATA AND INFLUENCE THE DESIGNS. THE REQUIREMENTS HAVE BEEN SORTED INTO CATEGORIES OF CONFIGURATION-COMMON AND CONFIGURATION-DEPENDENT.

* AREAS OF IMPACT-RECEIVING/HANDLING, ASSEMBLY, INTEGRATION, TEST/CHECKOUT, LAUNCH, ABORT/SCRUB, FRF, RECOVERY, DISASSEMBLY/SAFING, REFURBISHMENT.

TASK 2 - LRB REQUIREMENTS

- REQUIREMENTS CHECKLIST
  - ISSUES
  - 10 AREAS OF IMPACT
- GENERIC BASELINE CONFIGURATIONS
  - LOX/RP1
  - PUMP FED / PRESSURE FED
  - EXPENDABLE
- WORKING SESSIONS / VISITS WITH PHASE A CONTRACTORS
- INCORPORATE DATA FROM CONTRACTOR DOCUMENTATION

CONFIGURATION - COMMON REQUIREMENTS

THESE ARE THE REQUIREMENTS THAT ARE COMMON TO THE SIX "DOWN-SELECTED" LRB CONFIGURATIONS. GDSS HAS PROPOSED AN "ON SITE" MANUFACTURING FACILITY. THE SITE COULD BE ON THE BARGE CANAL IN WHICH CASE THE BOOSTERS WOULD ARRIVE AT LC39 VIA BARGE OR IT COULD BE AN LC39 LOCATION. IN EITHER CASE, NO SIGNIFICANT DIFFERENCE IN REQUIREMENTS IS SEEN AT THIS TIME WITH RESPECT TO RECEIVING/HANDLING. ON SITE MANUFACTURING,HOWEVER, MAY PRECLUDE THE NEED FOR A LRB HORIZONTAL PROCESSING FACILITY (HPF).

LAUNCH, ABORT/SCRUB AND FRF ARE COMBINED. WE FOUND NO COMMON OR UNIQUE REQUIREMENTS THAT DESCRIMINATE BETWEEN THESE AREAS OF IMPACT.

RECOVERY, DISASSEMBLY/SAFING AND REFURBISHMENT ARE COMBINED. THEY HAVE NO CURRENT REQUIREMENTS BECAUSE ALL SIX CURRENT LRB CONFIGURATIONS ARE EXPENDABLE.

TASK 2 - LRB REQUIREMENTS

CONFIGURATION - COMMON REQUIREMENTS

RECEIVING / HANDLING

- BARGE RECEIVING (2 LRBs PER)
- DEDICATED TRANSPORTER THRU INTEGRATION
- SELF CONTAINED TRANSPORTER ELECTRICAL & PURGE GSE
- GDSS ON-SITE MANUFACTURING

ASSEMBLY

- MINIMAL
- HORIZONTAL PROCESSING FACILITY (HPF)
- ET PROCESSING FACILITY (ETPF)

INTEGRATION

- STANDALONE DURING PROCESSING (MINI LPS)
- ENGINE CHANGE CAPABILITY AFTER STACKING
- LIFTING GSE
- NO BOOSTER UNIQUE ET INTERFACE
- SRB / LRB COMPATIBLE ORBITER HARDWARE
- NEW HOLDDOWN CONCEPT

TEST AND CHECKOUT

- NEW 'B' AND 'S' OMIs, SOME NEW 'V' OMIs
- NEW RSLS & GLS SOFTWARE
- MINI-LPS FOR HPF
- 3 X SRB LPS INCLUDING NEW ENGINE AND PROPELLANT CONSOLES
- NO TANK INTERIOR WORK

LAUNCH, ABORT / SCRUB AND FRF

- NO LRB LOX "BEENIE CAP"
- ADDITIONAL LOX AND NEW FUEL FACILITIES
- ONE NEW MLP, TWO MODIFIED MLPs
- NO LRB HYDRAULIC TVC
- FLAME DEFLECTOR / TRENCH - TBD
- NEW HGDS AND FIREX
- REWORK CRAWLERWAY
- LH2 VENT ARM MOD

RECOVERY, DISASSEMBLY / SAFING AND REFURBISHMENT

- NONE

CONFIGURATION - DEPENDENT REQUIREMENTS

THE MATRIX SHOWS REQUIREMENTS ASSOCIATED WITH SPECIFIC LRB CONFIGURATIONS AND AREAS OF IMPACT. THE TWO LONGEST BOOSTERS, B AND F, CAUSE ADDITIONAL REQUIREMENTS FOR FLOOR SPACE IN THE HPF, ADDITIONAL PLATFORM WORK IN THE VAB AND GOX VENT ARM MODS AND NOSE ACCESS AT THE PAD. THE TWO PRESSURE FED CONFIGURATIONS, A & B, REQUIRE PRESSURANT GSE AT THE PAD AND HPF. THE MMC DESIGNS, A & C, REQUIRE NOZZLE EXTENSION ASSEMBLY. A & C REQUIRE FLAME TRENCH AND FLAME DEFLECTOR REWORK. B,D,E & F REQUIRE ONLY DEFLECTOR REWORK. MMC DESIGNS, A & C, CAN BE ACCOMMODATED ON THE MLP WITH HOLD DOWN POSTS ONLY. A HAS A SERIOUS INTERFERENCE PROBLEM WITH MLP MAIN STRUCTURE (G20) WHICH MAY CAUSE A REQUIREMENT FOR ALL NEW MLP'S. NEW FLARE STACK, TSM AND VENT TOWER ARE REQUIRED FOR CH_4 AND LH_2. HANDLING AND LOGISTICS FOR CH_4 AND LH_2 WILL CREATE NEW TECHNOLOGY REQUIREMENTS FOR KSC.

THE LAUNCH PADS WILL REQUIRE THE MOST EXTENSIVE REWORK, THE GDSS LOX/RP1 PUMP-FED CAUSES THE LEAST REQUIREMENTS FOR KSC ESPECIALLY IF ON-SITE MANUFACTURING IS EMPLOYED.

LIQUID ROCKET BOOSTER INTEGRATION FIRST PROGRESS REVIEW

TASK 2 - LRB REQUIREMENTS

CONFIGURATION-DEPENDENT REQUIREMENTS

AREAS OF IMPACT / CONFIGURATION	1. RECEIVING/ HANDLING	2. ASSEMBLY	3. INTEGRATION	4. TEST/ CHECKOUT	5,6,7 LAUNCH ABORT/SCRUB. FRF	8,9,10 RECOVERY, DISASSEMBLY/ SAFING, REFURBISHMENT
A. LOX/RP1 PRESSURE MMC		NOZZLE EXTENSION		PRESSURANT GSE	PRESSURANT GSE F/T, DEFLECTOR HDP ONLY MLP G20 I/F	
B. LOX/RP1 PRESSURE GDSS	LONGEST- 200'	HPF + 25,000 S.F.	PLATFORM 'C' MODS	PRESSURANT GSE	PRESSURANT GSE GOX VENT ARM SIDE DEFLECTOR NOSE ACCESS	
C. LOX/RP1 PUMP MMC		NOZZLE EXTENSION			F/T, DEFLECTOR HDP ONLY	
D. LOX/RP1 PUMP GDSS					SIDE DEFLECTOR	
E. LOX/CH4 SPLIT EX GDSS					NEW VENT TOWER NEW FUEL TSM FLARE STACK SIDE DEFLECTOR FUEL TECHNOLOGY	
F. LOX/LH2 PUMP GDSS	LARGEST DIA.- 16'-2" LONG - 190'	HPF + 25,000 S.F.	PLATFORM 'C' MODS		GOX VENT ARM NEW VENT TOWER NEW FUEL TSM FLARE STACK NOSE ACCESS SIDE DEFLECTOR	

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TASK 2 - LRB REQUIREMENTS

- OPEN QUESTIONS AND ISSUES

  WILL THE REAL 'DOWNSELECTED' CONFIGURATIONS PLEASE STAND UP!

- WORK PLAN FOR NEXT PERIOD

  FREEZE DATA WITH PHASE-A FINAL

  COMPLETE ALL DATA POINTS

  BEGIN FINAL REPORT FORMATTING

LRB PROCESSING SUMMARY

THE LRB PROCESSING SCENARIO BEGINS AT KSC WITH BARGE DELIVERY, AND HORIZONTAL TRANSPORTER TOW TO THE NEW LRB PROCESSING FACILITY. HERE ALL STAND-ALONE BOOSTER CHECKOUT AND TESTING IS CONDUCTED. THE CONVERSION OF VAB/HB4 TO A FULL INTEGRATION CELL PERMITS LRB TRANSITION WITHOUT IMPACT TO ON-GOING SHUTTLE LAUNCHES.

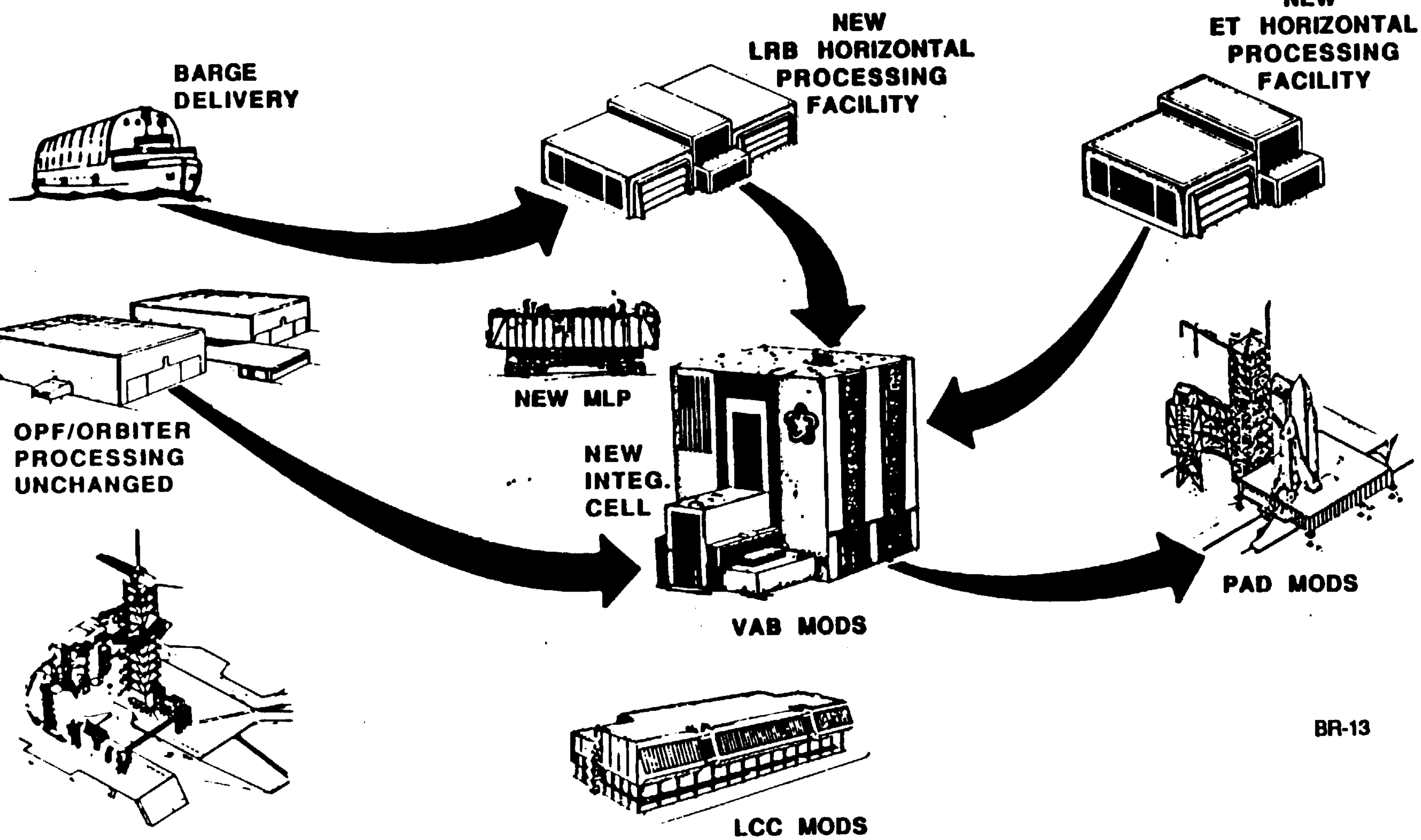
THE NEW ET HORIZONTAL PROCESSING FACILITY RELOCATES THE ET CHECKOUT AND STORAGE ACTIVITY SO THAT HB4 CAN BE USED. A NEW MLP CUSTOM-BUILT FOR LRB WILL BE CONSTRUCTED TO SUPPORT THE LRB IOC.

PAD MODS FOR OUR "BASELINE" LRB ARE MOSTLY ASSOCIATED WITH EXPANDED LOX CAPABILITY AND THE NEW FUEL STORAGE AND PUMPING SYSTEM. THE LAUNCH EQUIPMENT TEST FACILITY WILL BE MODED TO SUPPORT THE VALIDATION OF THE NEW LRB LAUNCH SUPPORT EQUIPMENT.

THE LAUNCH CONTROL CENTER FIRING ROOMS WILL BE MODIFIED TO SUPPORT THE NEW CONSOLES AND GROUND SOFTWARE FOR LRB PROCESSING AND LAUNCH OPERATIONS.

TASK 3 - PRELIMINARY LRB SCENARIOS

LRB PROCESSING SUMMARY



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SCENARIO GROUND RULES

BASIC GROUND RULES HAVE BEEN ESTABLISHED FOR THE PLANNED LRB SCENARIO AT THE LAUNCH SITE. CERTAIN FACILITIES ARE REQUIRED PRIOR TO IOC (FIRST LINE) AND ADDITIONAL FACILITY MODS AND ACTIVATION (SECOND AND THIRD LINE) ARE REQUIRED TO SUPPORT THE FULL TRANSITION AND LRB LAUNCH RATE BUILD UP.

TASK 3 - PRELIMINARY SCENARIOS

SCENARIO GROUNDRULES

- LRB TRANSITION IS PLANNED TO YIELD MIN IMPACTS TO ONGOING KSC LAUNCH OPERATIONS
- FIRST-LINE FACILITY ACTIVATIONS WILL SUPPORT 1996 FIRST FLIGHT AND A BUILD-UP TO AN ANNUAL 3 LRB LAUNCH RATE
- A FIVE-YEAR TRANSITION TO FULL FLIGHT RATE OF 14 IS PLANNED OVER 1996 TO 2000. SECOND AND THIRD LINE FACILITY ACTIVATIONS ARE PLANNED TO SUPPORT THIS BUILD-UP
- SHARED FACILITY UTILIZATION FOR THE MIXED FLEET OPERATIONS ARE PLANNED TO SUPPORT SHUTTLE LAUNCH MANIFEST DURING TRANSITION.

SCENARIO FEATURES

THROUGH OUR INTEGRATION EFFORTS WITH THE OTHER NASA CENTERS AND THE LRB PHASE A CONTRACTORS WE HAVE BEEN ABLE TO DEVELOP THE MOST LIKELY SCENARIO. AT THIS TIME, WE ENVISION ONLY TWO MAJOR PROCESSING ALTERNATIVES. ONE IS OFF-SITE (NOT LC39) MANUFACTURE AND THE OTHER USES ON-SITE MANUFACTURE.

THE BOOSTERS ARE RECEIVED BY BARGE (OFF-SITE MANUFACTURE) AND MOVED TO THE HPF FOR ASSEMBLY, TEST AND CHECKOUT. BOOSTERS, ET AND ORBITER ARE TAKEN TO THE VAB HB 3 OR 4 FOR INTEGRATION ON A NEW OR MODIFIED MLP. THE INTEGRATED STACK IS MOVED TO THE PAD FOR INTEGRATED TESTING, PROPELLANT LOADING, FRF AND LAUNCH.

TASK 3 - PRELIMINARY LRB SCENARIOS

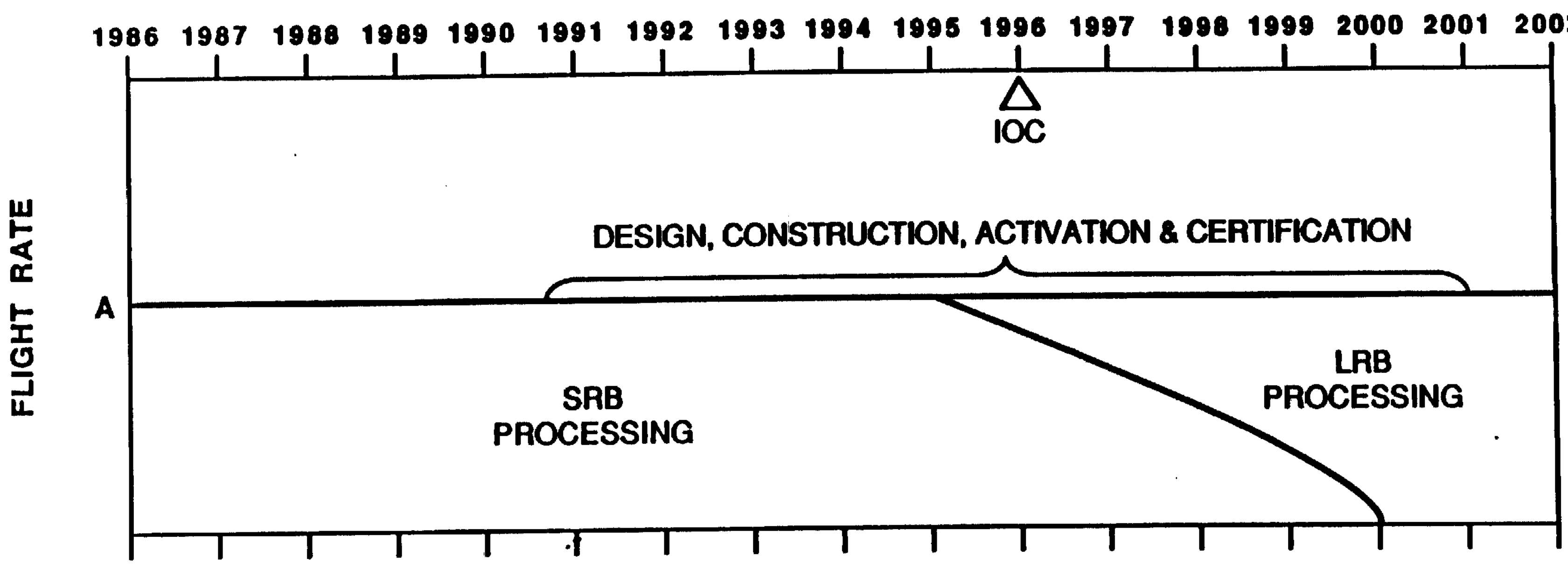
- SCENARIO FEATURES
  - BARGE DELIVERY OR LC-39 MANUFACTURE
  - LRB HORIZONTAL PROCESSING FACILITY (WITH SURGE)
  - ET PROCESSING FACILITY
  - VAB HB 3 / 4
  - NEW MLP / MOD TWO MLP
  - PAD PROCESSING

THE LRB FLIGHT RATE IS SHOWN TO FOLLOW A RAMP OF 3, 6, 9, 12, 14 FLIGHTS PER YEAR. SRB IS ASSUMED TO DECREASE AT A COMPLEMENTARY RATE (11, 8, 5, 2, 0 REPSECTIVELY) TO MAINTAIN A CONSTANT FLIGHT RATE OF 14 PER YEAR DURING THE TRANSITION PERIOD. TRANSITION IS TO OCCUR OVER THE FIVE YEAR PERIOD 1996-2000. OTHER RAMPING SCHEMES ARE BEING PROPOSED BY OTHER GROUPS. HOWEVER, THE ONE SHOWN IS GROUND RULED FOR THIS STUDY AND IS THE BASIS FOR OUR LRB IMPLEMENTATION PLANS. NO EFFECTS OF OTHER PROGRAMS (ASRM, ALS, SHUTTLE II, SHUTTLE C) ARE SHOWN.

LIQUID ROCKET BOOSTER INTEGRATION FIRST PROGRESS REVIEW

JULY 1988

TASK 3 - PRELIMINARY LRB SCENARIOS



FLIGHTS	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
SRB					14	14	14	14	14	14	11	8	5	2			
LRB											3	6	9	12	14	14	14

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TASK 3 - PRELIMINARY LRB SCENARIOS

- OPEN QUESTIONS AND ISSUES
  - SITING FOR HPF AND ETPF (COMMON OR SEPARATE)
  - HPF VS ON-SITE MANUFACTURING
- WORK PLAN FOR NEXT PERIOD
  - FINALIZE PROCESSING SCENARIOS AND IDENTIFY ALL MAJOR DELTAS FOR EACH CONFIGURATION

LIQUID ROCKET BOOSTER INTEGRATION FIRST PROGRESS REVIEW

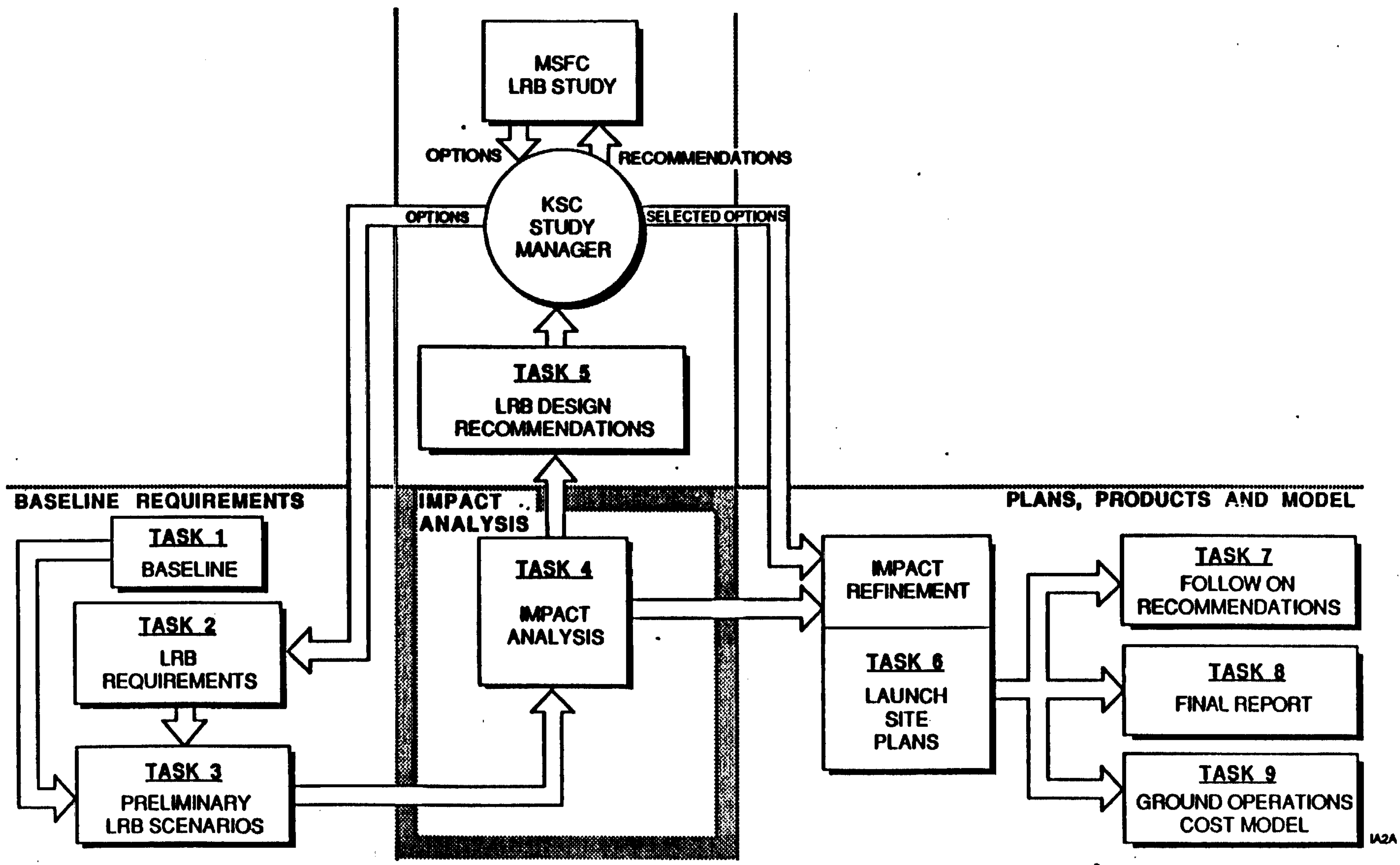
JULY 1988

AGENDA

I.	INTRODUCTION	GORDON ARTLEY
II.	STUDY PROGRESS	
	A) LRB PROJECT INTEGRATION	PAT SCOTT
	B) BASELINE REQUIREMENTS	KEITH HUMPHRYES
	C) IMPACT ANALYSIS	GREG DEBLASIO
	D) PLANS, PRODUCTS AND MODEL	JERRY LEFEBVRE
III.	SUMMARY	GORDON ARTLEY

IMPACT ANALYSIS

JULY 1988



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IMPACT ANALYSIS

- PROGRESS / RESULTS / STATUS
  - LRB AND ET PROCESSING FACILITY
  - INTEGRATION FACILITY (VAB)
  - MLP
  - LAUNCH PAD
  - PROPELLANT FACILITIES
  - LCC
  - LC-39
  - LETF
  - SAFETY / ENVIRONMENTAL
- OPEN ISSUES / PROBLEMS
- NEAR-TERM PLANS

LRB/ET PROCESSING FACILITY

THE GROUNDRULE, PRESENTED IN THE BASELINE AND SCENARIO PLANNING, OF INTRODUCTING LRBS TO KSC WITHOUT IMPACTS TO EXISTING FACILITIES AND OPERATIONS DRIVES A REQUIREMENT TO STUDY AN OFF-LINE LRB PROCESSING FACILITY. THIS SCENARIO ALSO SHOWS THAT TO MAINTAIN THE PLANNED LAUNCH RATE A THIRD INTEGRATION CELL IN THE VAB IS REQUIRED. A STUDY TO PROVIDE AN OFF-LINE ET PROCESSING FACILITY IS ALSO BEING CONDUCTED.

LRB / ET PROCESSING FACILITY

- LRB PROCESSING FACILITY LAYOUT
- LRB PROCESSING REQUIREMENTS
- ET PROCESSING FACILITY LAYOUT
- LRB / ET PROCESSING FACILITY - SITING
- ET / LRB PROCESSING FACILITY CONTROL CENTER & LPS REQUIREMENTS

LRB PROCESSING FACILITY LAYOUT

THE OFF-LINE FACILITY FOR PROCESSING AND STORAGE OF LRBS BEING PROPOSED WILL PROVIDE FOR LRB COMPONENT & SUBSYSTEM FINAL CHECKOUT AND FLIGHT CERTIFICATION, LRU REPLACEMENT AND ENGINE REMOVAL/INSTALLATION. SPACE FOR GSE AND MINI-LPS IS PROVIDED ALONG WITH AN ENGINE SHOP, BATTERY SHOP AND LRU STORAGE.

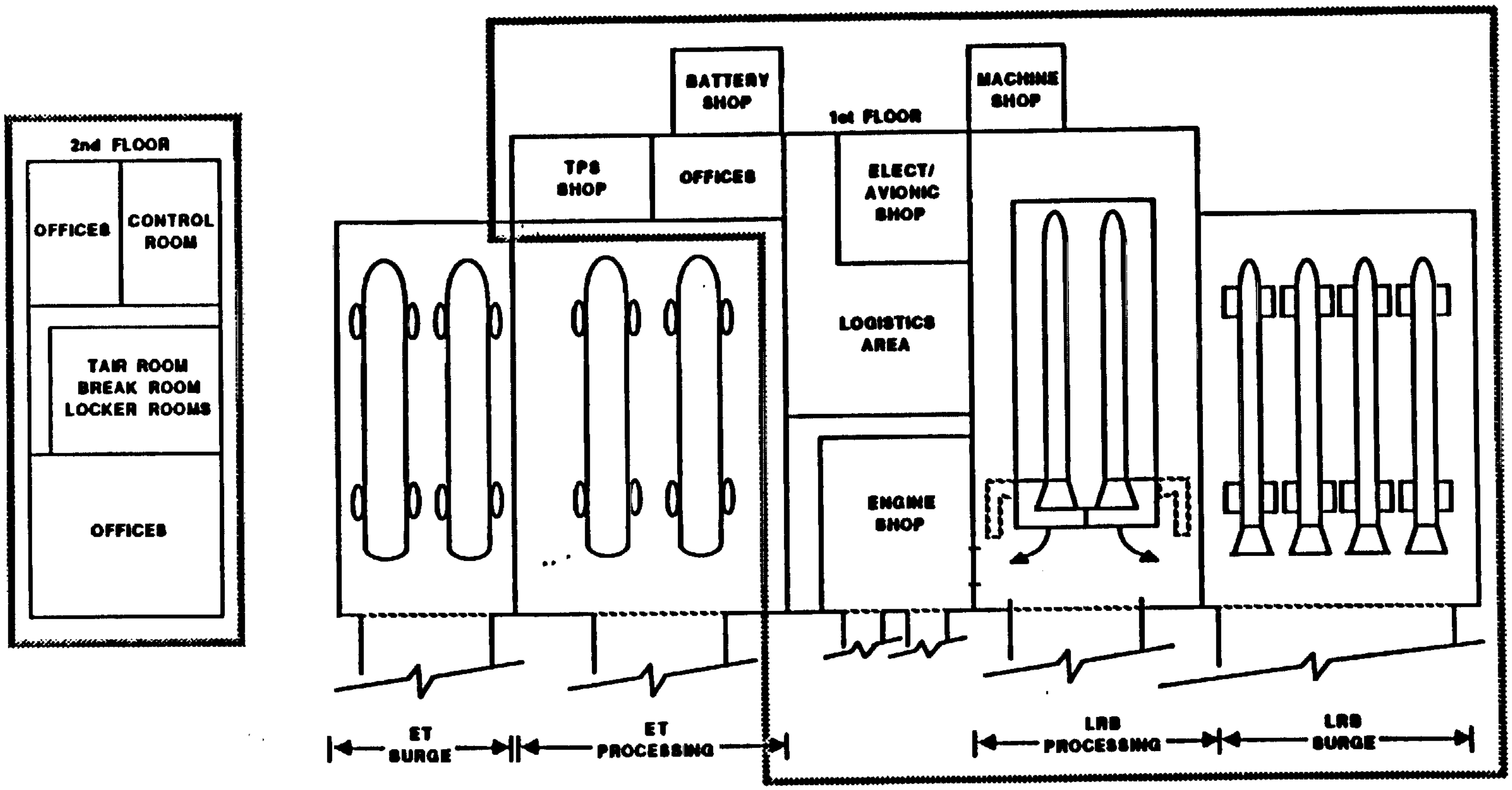
THE PROPOSED FACILITY WILL PROVIDE THE CAPABILITY TO PROCESS A LRB PAIR FOR FLIGHT AND STORE TWO PAIRS OF LRB BOOSTERS.

THE FACILITY WILL REQUIRE UTILITIES AS FOLLOWS:

PNEUMATICS:	GHE DISTRIBUTION, GN2 DISTRIBUTION, COMPRESSED AIR DISTRIBUTION, BREATHING AIR DISTRIBUTION SYSTEMS, ECS
ELECTRICAL:	AC POWER, DC POWER (CONTROLS)
FIRE CONTROL:	FIREX WATER, HALON, DRY CHEMICAL (AS REQUIRED)
COMMUNICATIONS:	PA SYSTEM, OIS (VOICE RECORDER SYSTEM).
UTILITIES:	POTABLE WATER, SEWAGE

LIQUID ROCKET BOOSTER INTEGRATION FIRST PROGRESS REVIEW

LRB PROCESSING FACILITY LAYOUT



SQUARE FOOTAGE
150,000 MINIMUM
175,000 MAXIMUM

LRB PROCESSING REQUIREMENTS

THE GSE REQUIRED TO SUPPORT VARIOUS FUNCTIONAL PROCESSING TASKS FOR THE LRB BOOSTERS (AVIONICS, TANKS AND ENGINES) IS BEING COMPILED.

THE CONTROLS/SOFTWARE-HARDWARE REQUIREMENTS ARE ALSO BEING COMPILED INCLUDING THE CONTROL ROOM REQUIREMENTS.

LRB PROCESSING REQUIREMENTS

LRB FUNCTIONAL TEST AND OPS

- PRESSURE MONITORING
- VENT VALVE FUNCTIONAL
- TANK PURGE / SAMPLING
- LEAK / FLOW TEST
- DISCONNECT VALVE MEASUREMENTS
- TANK LEAK TEST
- INSTALLATION OF FLIGHT ACCESSORIES
- ASCENT AIR DATA SYSTEM (AADS) ALIGNMENT
- INTERTANK ACCESS OPS
- SUPPORT FIXTURE VERIFICATION
- NOSE FAIRING OPS
- ENGINE LEAK / FUNCTIONAL
- LEAK CHECK OF PRESSURIZED SYSTEMS
- INTERFACE LEAK CHECKS
- ENGINE REMOVAL / INSTALLATION
- LRB MOVE OPERATIONS

GSE REQUIREMENTS

- HEATED PNEU PANELS
- PNEU C / O PANELS
- VENT VLV & RV C / O KIT
- VENT VLV ACTUATION PANEL
- LEAK RATE COUNTER
- *INTERTANK GRD UMB CARRIER
- 02 MONITORING EQUIPMENT
- DEW POINT SAMPLING EQUIP
- *DISCONNECT ADAPTER PLATE
- *DISCONNECT VLV OPERATOR
- GHE PURITY SAMPLING EQUIP
- INTERTANK ACCESS KIT
- PORTABLE LIGHTS
- *I / F SLAVE UNITS
- *AADS VERIF SET
- AADS ACCESS PLATFORM
- *CLOSURE KITS
- *NOSE SPIKE PROTECTIVE COVER
- C / O CELL FIXTURES
- *ACCESS DOOR SILL PROTECTORS
- *PYRO STRUT UNIT
- ECS UNITS
- PNEU REGULATION / SERVICE PANELS
- SLINGS
- ALIGNMENT TOOLS
- HOISTS
- MASS SPEC EQUIPMENT
- CRANES
- TOW TRACTOR
- ELECTROLYTIC MOISTURE MONITOR
- TRANSPORT FITTING HANDLING SET
- ENGINE ERECTION SLING
- ENGINE SLING SET
- *LRB TRANSPORTER

H/W REQUIREMENTS

- FEP(S)
- HIM(S)
- CONSOLES
- DATA LINK EQUIP
- COMPUTER SYS
- CABLING
- TERMINAL DISTR
- FIRE CONTROL EQUIP / SYS
- OLSA (OR EQUIV) (SIGNAL CONDITIONER)

S/W REQUIREMENTS

- VENT VLV ACTUATION / TIMING
- PNEU SYS COMMAND / RESPONSE
- OI / DFI POWER ON / OFF
- PURGE SEQ CONTROLS
- DISPLAYS / SKELETONS
- GSE LINKS
- VEHICLE LINKS
- ENGINE AUTO POWER ON/OFF
- ENGINE MONITORING
- ENGINE COMMANDS
- ENGINE AUTO C/O SEQ
- DEFAULT DISPLAY
- FAILURE DECODER
- SYSTEM MANAGER

*LRB CONTRACTOR SUPPLIED

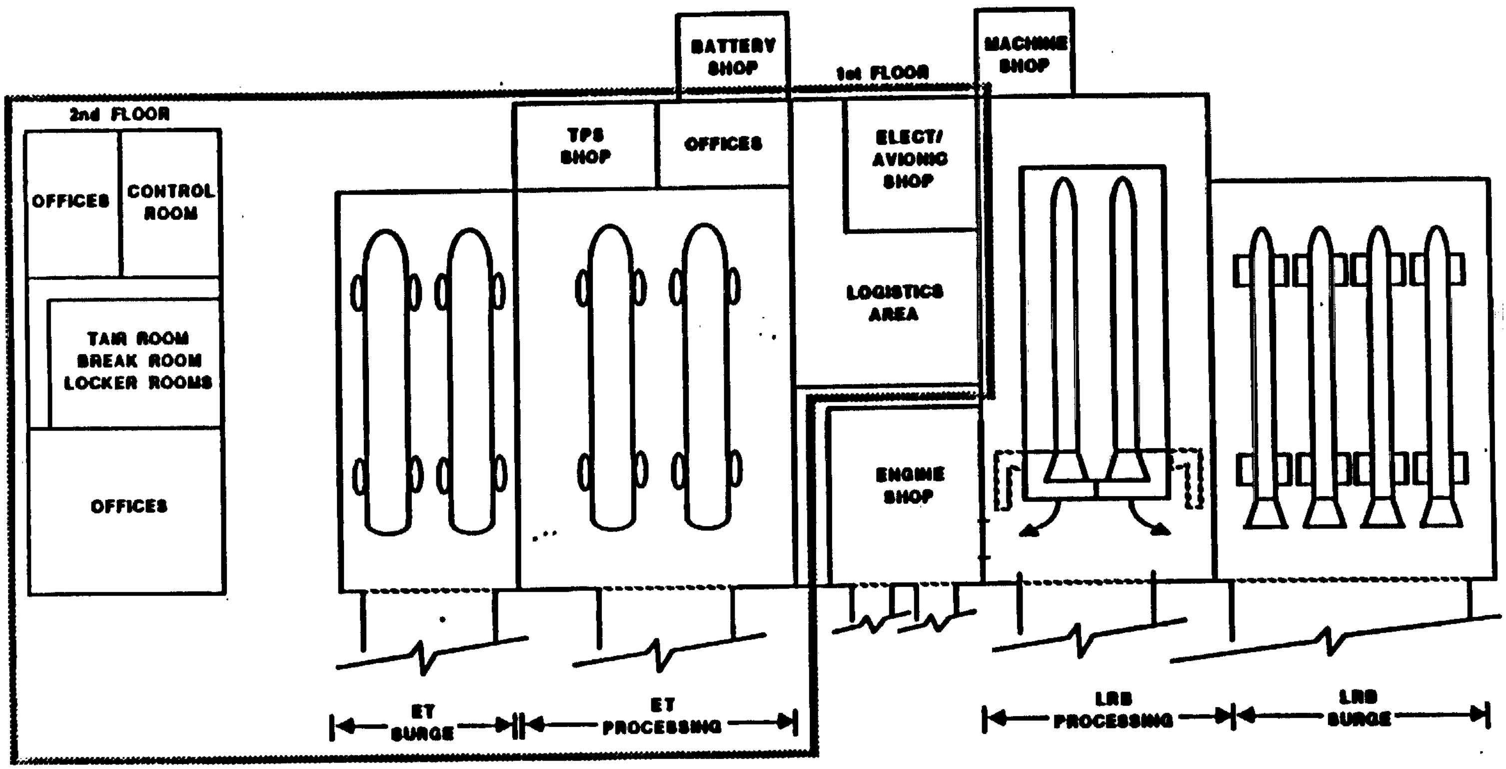
ET PROCESSING FACILITY LAYOUT

TO ALLOW VAB HB4 TO BE USED FOR STS/LRB INTEGRATION, ET STORAGE AND PROCESSING MUST BE MOVED TO AN OFF-LINE FACILITY. THE PROPOSED FACILITY CAN BE COMBINED WITH THE NEW LRB PROCESSING FACILITY AND SHARE OFFICE, SHOP AND CONTROL ROOM SPACE.

THE FACILITY UTILITY REQUIREMENTS WILL BE THE SAME AS LRB AND WILL BE SHARED.

ALL OPERATIONS PRESENTLY PERFORMED ON THE ET IN HB4 CAN BE ACCOMPLISHED IN THE HORIZONTAL POSITION.

ET PROCESSING FACILITY LAYOUT



SQUARE FOOTAGE
150,000 MINIMUM
175,000 MAXIMUM

ET/LRB PROCESSING FACILITY - SITING

THE SITE SELECTION TRADE STUDY FOR THIS FACILITY IS IN PROGRESS. FOUR (4) LC-39 AREA SITES ARE UNDER REVIEW.

1. SOUTH OF THE LOGISTICS FACILITY ON CONTRACTOR'S ROAD
2. SOUTH OF THE TURN BASIN ADJACENT TO THE PRESS SITE
3. SOUTHWEST OF THE VAB AND EAST OF MFF, CURRENTLY A PARKING LOT
4. NORTH OF THE VAB AND EAST OF THE OMRF

PRIMARY TRADE SELECTION CRITERIA INCLUDES -

1. SSV INTEGRATION FACILITY PROXIMITY
2. TURN BASIN PROXIMITY
3. BLAST DANGER AREA (QUANTITY/DISTANCE)
4. LAUNCH DANGER AREA
5. ENVIRONMENTAL IMPACTS
6. ET & LRB TOW ROUTES
7. LC-39 AREA CONGESTION
8. AVAILABILITY OF UTILITIES/SERVICES
9. DEMOLITION AND RELOCATION OF EXISTING FACILITIES
10. SITE PREPARATION COSTS

ANY SITE IN THE DIRECTION OF SWARTZ ROAD IS PREFERRED TO ELIMINATE CONGESTION AND TRAFFIC CONCERN AND IMPACT TO CURRENT UTILITIES AND SERVICES IN THE LC39 AREA.

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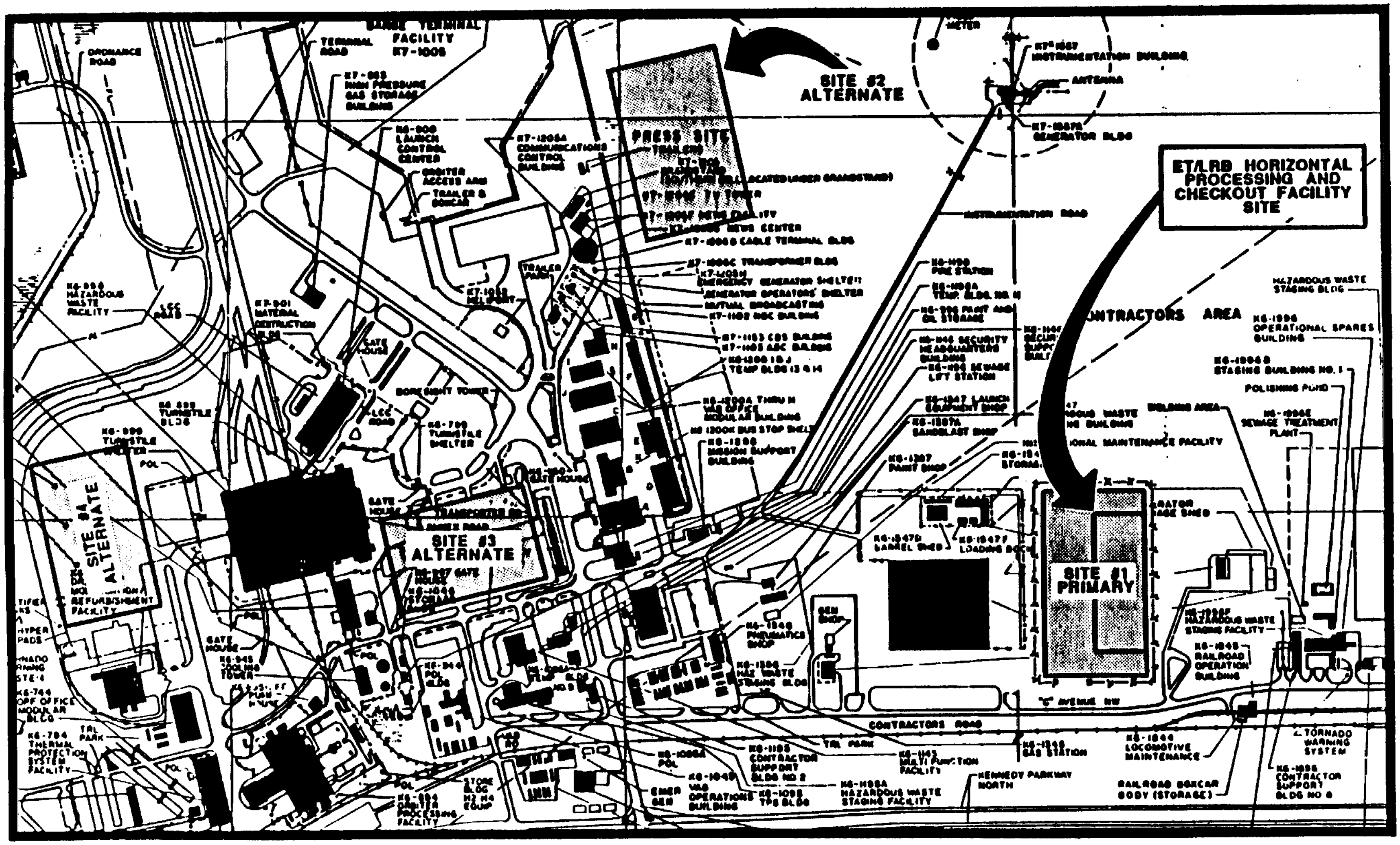
ET/LRB PROCESSING FACILITY - SITING



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ET/LRB PROCESSING FACILITY CONTROL CENTER & LPS REQUIREMENTS

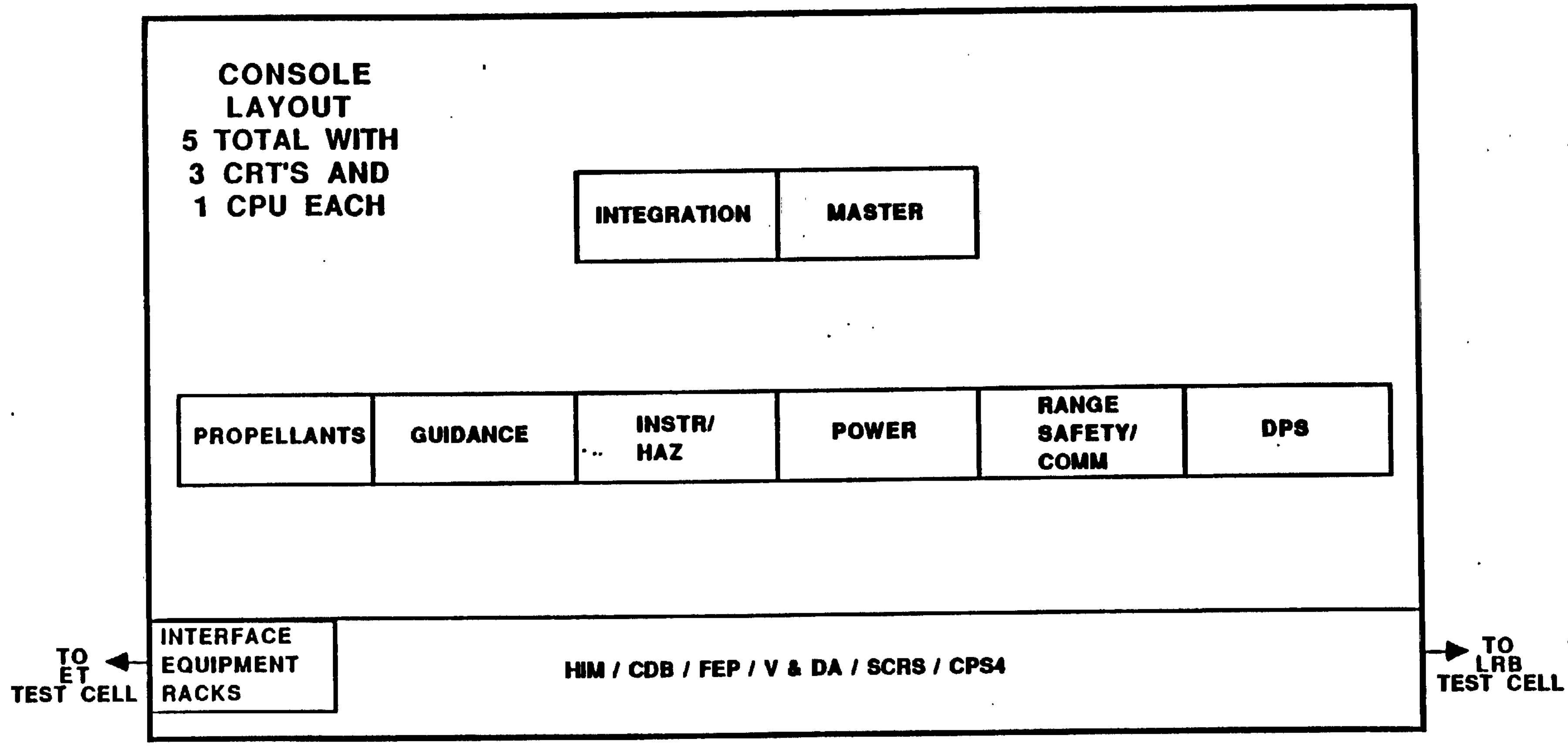
LRB PROCESSING FUNCTIONS IN THE NEW FACILITY INCLUDE COMPONENT AND SUBSYSTEM CHECKOUT, WITH LPS SUPPORT. TO AVOID A LCC IMPACT, AN INDEPENDENT CONTROL ROOM CONCEPT CONFIGURED LIKE A MINI-LCC, IS UNDER REVIEW.

EACH OPERATIONS SYSTEM ENGINEER WILL BE REQUIRED TO HAVE A CONSOLE WHILE PERFORMING FUNCTIONAL TESTING OF BOTH SETS OF LRB'S. CHECKOUT WILL INCLUDE ENGINE, AVIONICS, INSTRUMENTATION, POWER & GIMBALING TESTS. LISTED BELOW IS A GENERAL LIST OF EQUIPMENT REQUIRED FOR THE LRB/ET FACILITY CONTROL ROOMS:

- 1 - O.L.S.A
- 1 - HARDWARE INTERFACE MODULE (HIM)
- 1 - COMMON DATA BUFFER
- 1 - SCRS
- 1 - CPS4
- 1 - V & DA
- 5 - CONSOLES (CPU INCLUDED) FOR: PROPELLANTS, GUIDANCE, INSTR/HAZ, POWER, RANGE SAFETY/COMM, DPS, INTEGRATION, MASTER
- 1 - FEP

ET HORIZONTAL PROCESSING CAN BE SUPPORTED WITH THIS EQUIPMENT AS WELL.

ET / LRB PROCESSING FACILITY CONTROL CENTER & LPS REQUIREMENTS



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INTEGRATION FACILITY

- VAB PLATFORMS (HB-3)
- VAB PLATFORM (HB-3) MODIFICATION
- VAB EXIT / PLATFORM INFRINGEMENT
- VAB HB DOOR CLEARANCE
- VAB HIGH BAY 4
- VAB HIGH BAY 4 CRAWLERWAY

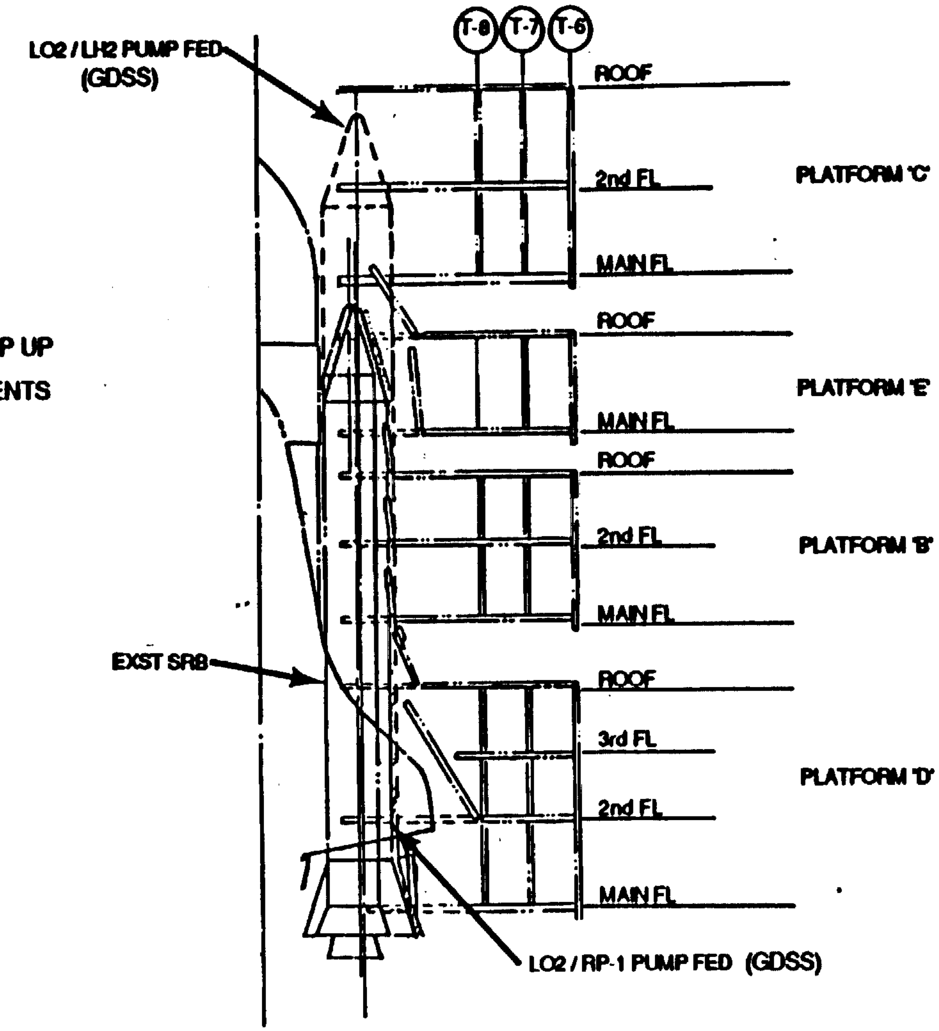
VAB PLATFORMS (HB 3)

THE PLATFORM MODIFICATIONS AT VARIOUS LEVELS IS DEPENDENT ON THE LENGTH AND DIAMETER OF THE LRB. THE WORST CASES FOR LENGTH ARE THE GDSS LOX/LH2 PUMP-FED AND GDSS LOX/RPI PRESSURE-FED CONFIGURATIONS. THE DIAMETERS OF ALL LRB CONFIGURATIONS IMPACT THE EXTENSIBLE PLATFORMS/FLIP-UPS ENCOUNTERED. THE PRESENT REQUIREMENT FOR CLEARANCE OF STEEL TO FLIGHT HARDWARE IS 6" (STATIC).

USING THE MMC LOX/RP1 PUMP-FED CONFIGURATION AS A BASELINE, IT IS NOTED THAT EXTENSIVE MODIFICATIONS ARE REQUIRED. ALL FLOORS OF PLATFORM LEVELS "D," "B," & "E" WILL REQUIRE MODIFICATIONS. THE FLIP-UP/EXTENSIBLE PLATFORMS WILL REQUIRE REDESIGN TO PROVIDE DUAL CAPABILITY, LRB OR SRB. FOR THE GDSS LOX/LH_2 PUMP-FED AND GDSS LOX/RP1 PRESSURE-FED CONFIGURATIONS, MODIFICATIONS TO PLATFORM "C" WILL BE REQUIRED.

VAB PLATFORMS (HB-3)

MINIMUM PLATFORM / FLIP UP
CLEARANCE REQUIREMENTS
6" EXTENDED
1-6" RETRACTED



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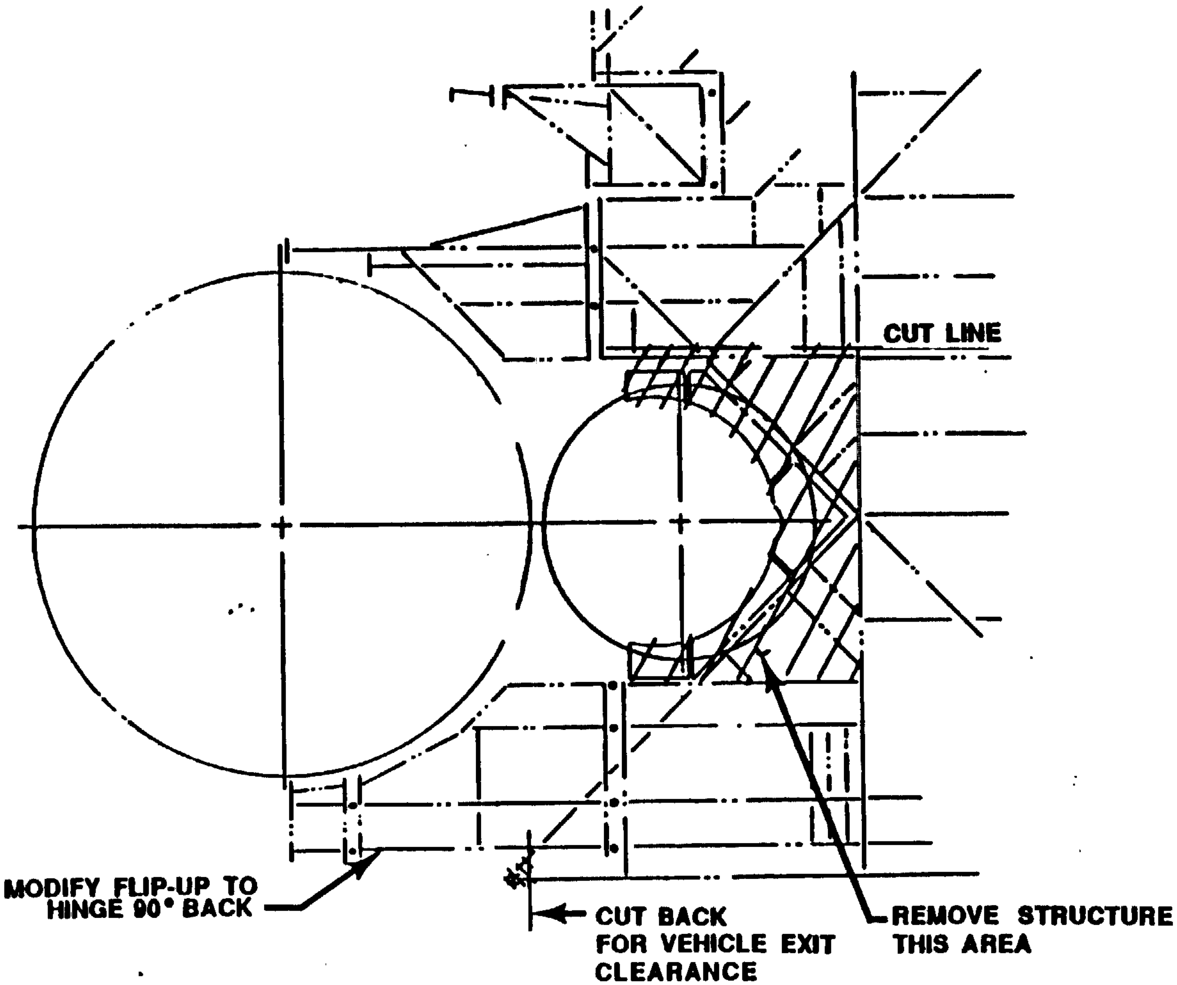
VAB PLATFORM (HB-3) MODIFICATION



TYPICAL MODIFICATION
(ROOF OF PLATFORM 'D' SHOWN)

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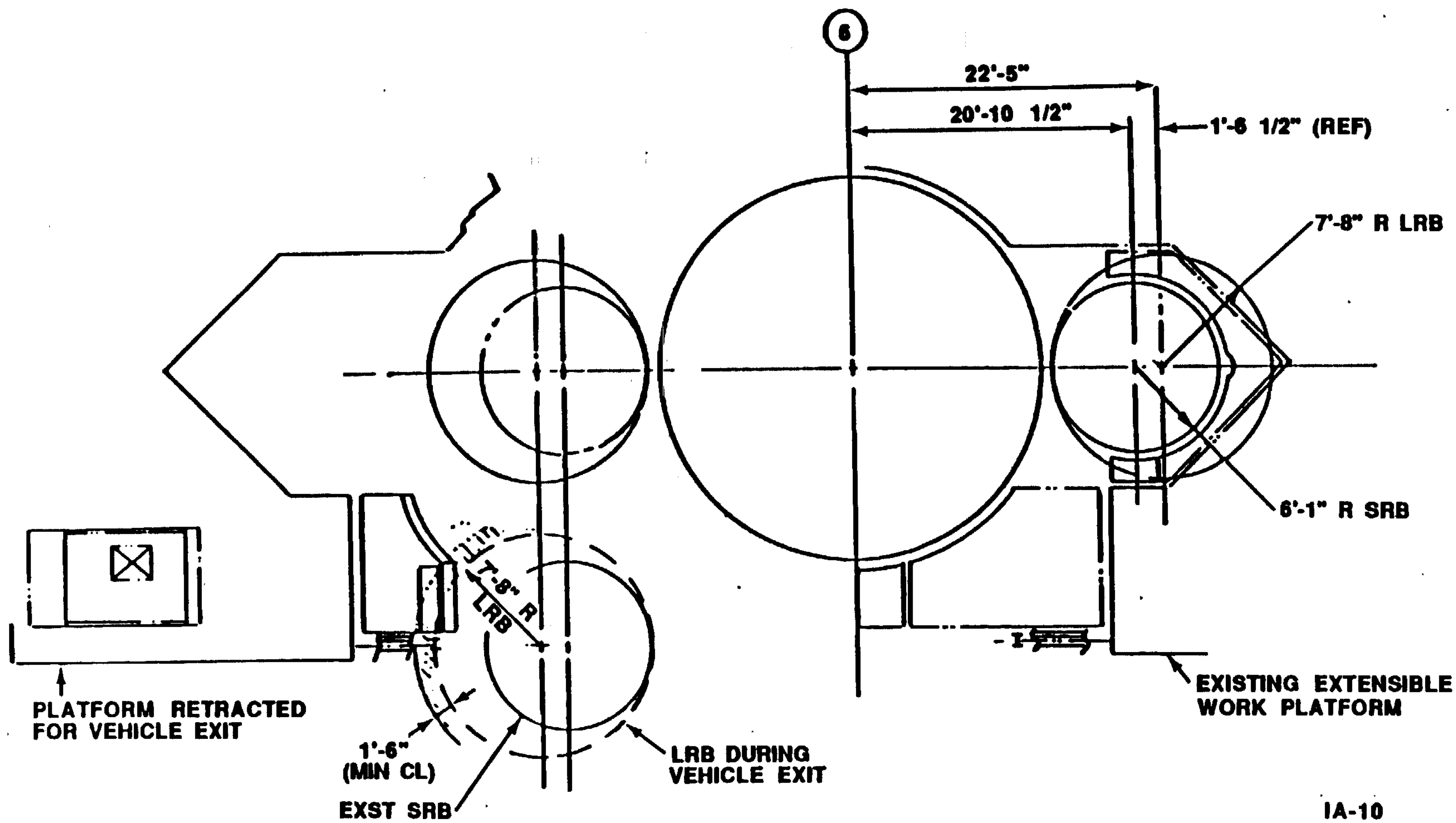
VAB HB 3 EXIT/PLATFORM INFRINGEMENT

A MINIMUM CLEARANCE OF 1′ - 6″ WILL BE REQUIRED FOR FLIGHT HARDWARE TO STRUCTURE DURING VAB EGRESS. ALL LRB CONCEPTS IMPACT THE RETRACTED PLATFORM/FLIP-UPS AT PLATFORMS "D," "B," & "E." THE GDSS LOX/LH2 PUMP-FED AND GDSS LOX/RP1 PRESSURE-FED CONFIGURATIONS WILL IMPACT PLATFORM "C"

VAB EXIT / PLATFORM INFRINGEMENT



IA-10

PLAN VIEW
LO2 / RP-1 PUMP FED (MMC)

VAB HIGH BAY DOOR CLEARANCE

- All LRB Configurations clear the VAB doors

LRB TYPE	BOOSTER DIA.	CLEARANCE
GDSS LO2/RP1 (PUMP FED)	14'-1"	6'-8"
GDSS LO2/RP1 (PRESSURE)	15'-0"	5'-9"
GDSS LO2/LH2	16'-2"	4'-7" (SHOWN)
GDSS LO2/CH4	15'-0"	5'-9"
MMC LO2/RPI (PUMP FED)	15'-4"	5'-5" (SHOWN)
MMC LO2/RPI (PRESSURE)	16'-2"	4'-7"
PRESENT SRB	12'-2"	8'-7" (SHOWN)

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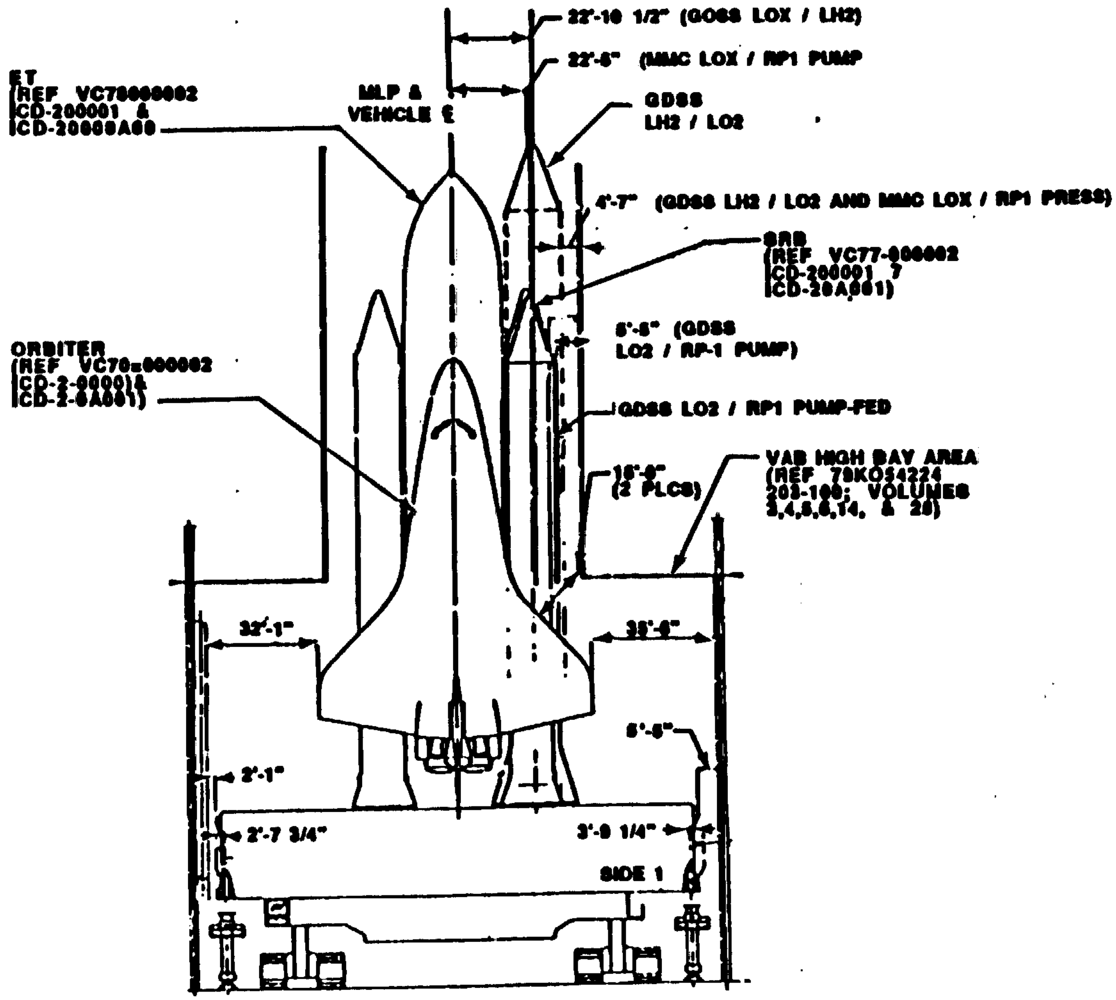
VAB HIGH BAY DOOR CLEARANCE



CRAWLER, MLP & VEHICLE IN TRANSIT THROUGH VAB DOORS (EAST)

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VAB HIGH BAY 4

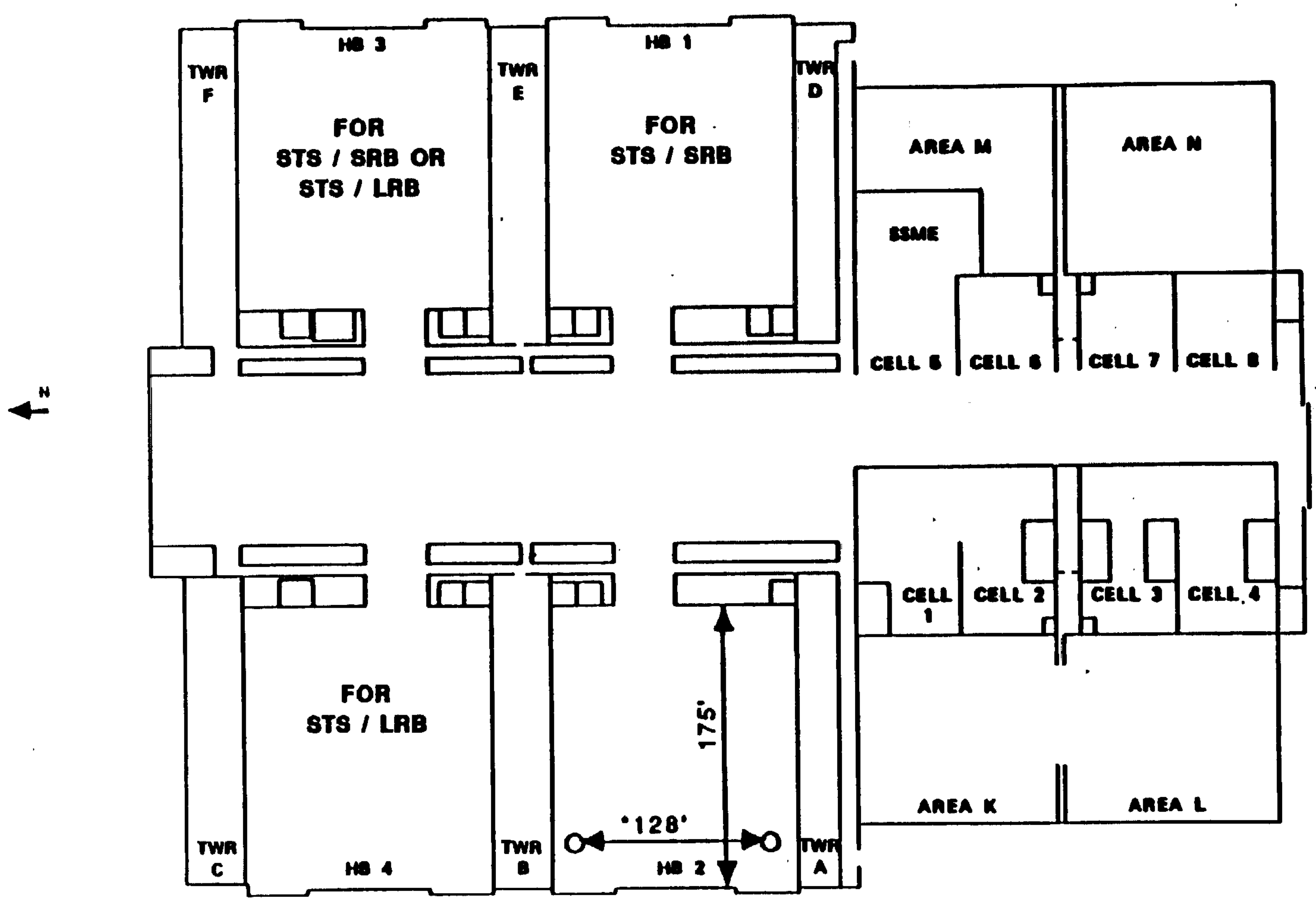
DEMOLITION OF EXISTING VEHICLE ACCESS STRUCTURES IS REQUIRED. THIS INCLUDES REMOVAL OF SRB WORK STANDS AND ET CHECKOUT CELLS (ET CHECKOUT EQUIPMENT WILL BE MOVED TO THE NEW ET FACILITY AND THE SRB WORK STANDS CAN BE RELOCATED TO VAB HB2 AS BACKUP TO THE RPSF.)

NEW ORBITER, ET, AND LRB ACCESS PLATFORMS WILL BE PROVIDED. THE PLATFORM SYSTEM WILL BE SIMILAR TO THOSE IN HB 1/3 BUT WILL BE CUSTOMIZED TO PROVIDE ACCESS TO THE ORBITER, ET AND LRB. THE LRB ACCESS WILL INCLUDE AFT SKIRT, INTERTANK AREA AND NOSE. THE REQUIRED ORBITER/ET ACCESS WILL INCLUDE THE 2ND AND MAIN FLOOR OF PLATFORM "D" (WILL ALSO PROVIDE ACCESS TO LRB AFT SKIRT), ROOF & 2ND FLOOR OF PLATFORM "B" AND MAIN FLOOR OF PLATFORM "E."

THE TWO LONGEST BOOSTER CONFIGURATIONS WILL REQUIRE ADDITIONAL PLATFORMS SIMILAR TO "C" IN HB 1/3.

THE HIGH BAY WILL REQUIRE INSTALLATION OF GSE TO PERFORM INTEGRATION TESTING OF THE ET/ORBITER IDENTICAL TO HB 1/3. NEW LRB INTEGRATION TEST GSE WILL ALSO BE INSTALLED.

VAB HIGH BAY 4



• BETWEEN MLP POSTS

VAB FLOOR PLAN

VAB HB-4 CRAWLERWAY

IN ORDER TO USE VAB HB-4 AS A STS/LRB INTEGRATION FACILITY, REACTIVATION OF THE HIGH BAY CRAWLERWAY IS REQUIRED.

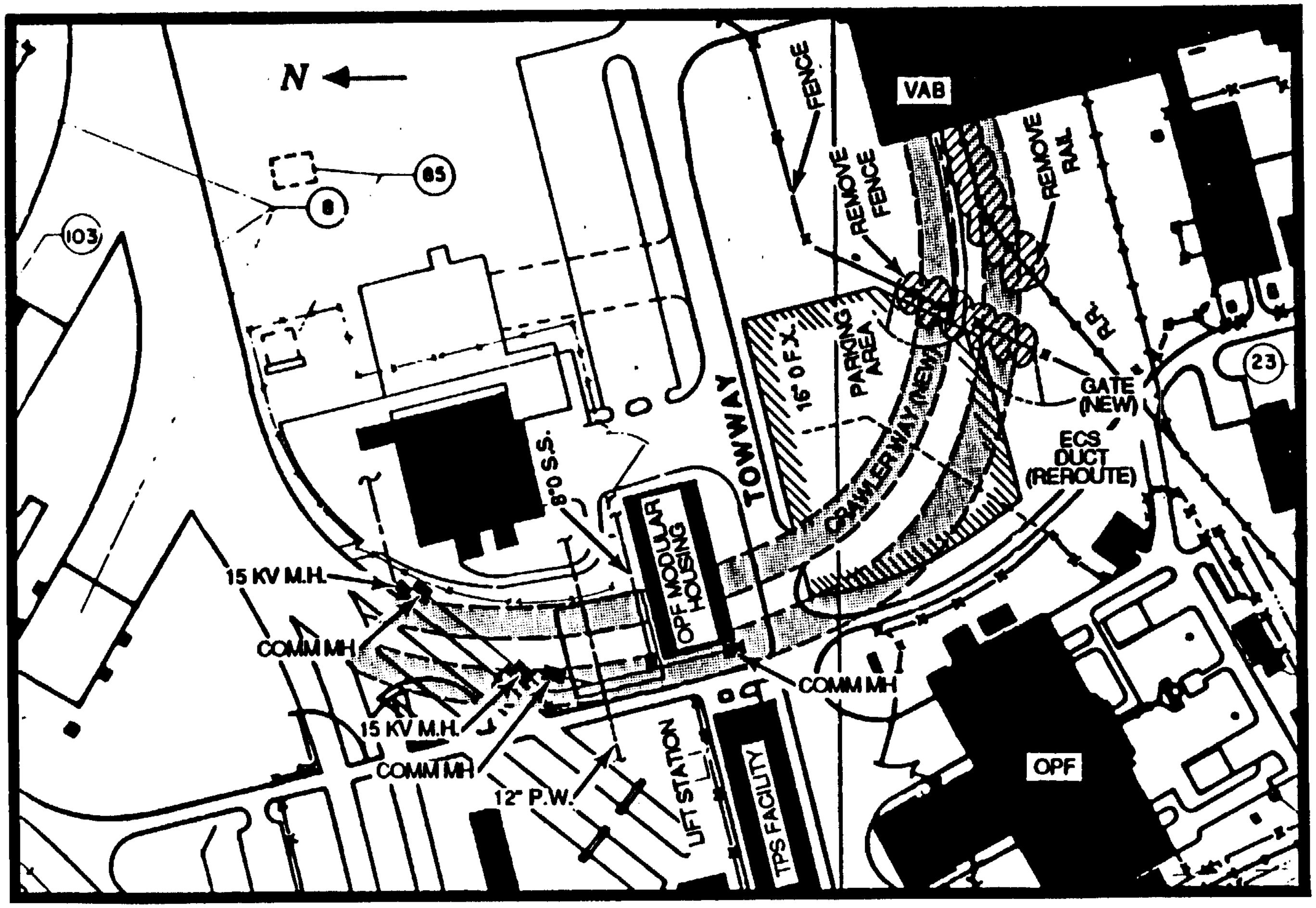
THE OPF MODULAR HOUSING, OPF EAST PARKING LOT AND A SECTION OF THE ORBITER TOW-WAY WILL BE DEMOLISHED.

PARALLEL POWER, COMMUNICATION AND MECHANICAL SERVICES WILL BE INSTALLED PRIOR TO THE DEMOLITION OR ABANDOMMENT IN PLACE OF EXISTING SERVICES.

DEMOLITION OF THE OPF MODULAR HOUSING WILL DISPLACE APPROXIMATELY 100 PERSONNEL AND WILL REQUIRE SITING OF ALTERNATE WORK SPACE.

FURTHER STUDY IS REQUIRED TO CONCEPT AN INTERSECTION OF THE CRAWLERWAY AND ORBITER TOW-WAY.

VAB HB-4 CRAWLER WAY



MLP

A MAJOR CONCERN FOR MODIFICATION OF THE MLPS IS IMPACTS TO THE G-20 GIRDER. G-20 IS THE PRIMARY STRUCTURAL MEMBER OF THE GIRDER SYSTEM. ANOTHER CONCERN WITH THE SSME AND BOOSTER EXHAUST HOLE ARRANGEMENT IS THE IMPACT ON THE SIZE OF THE SSME EXHAUST HOLE. FURTHER STUDY IS REQUIRED FOR BOTH CONCERNS.

MLP

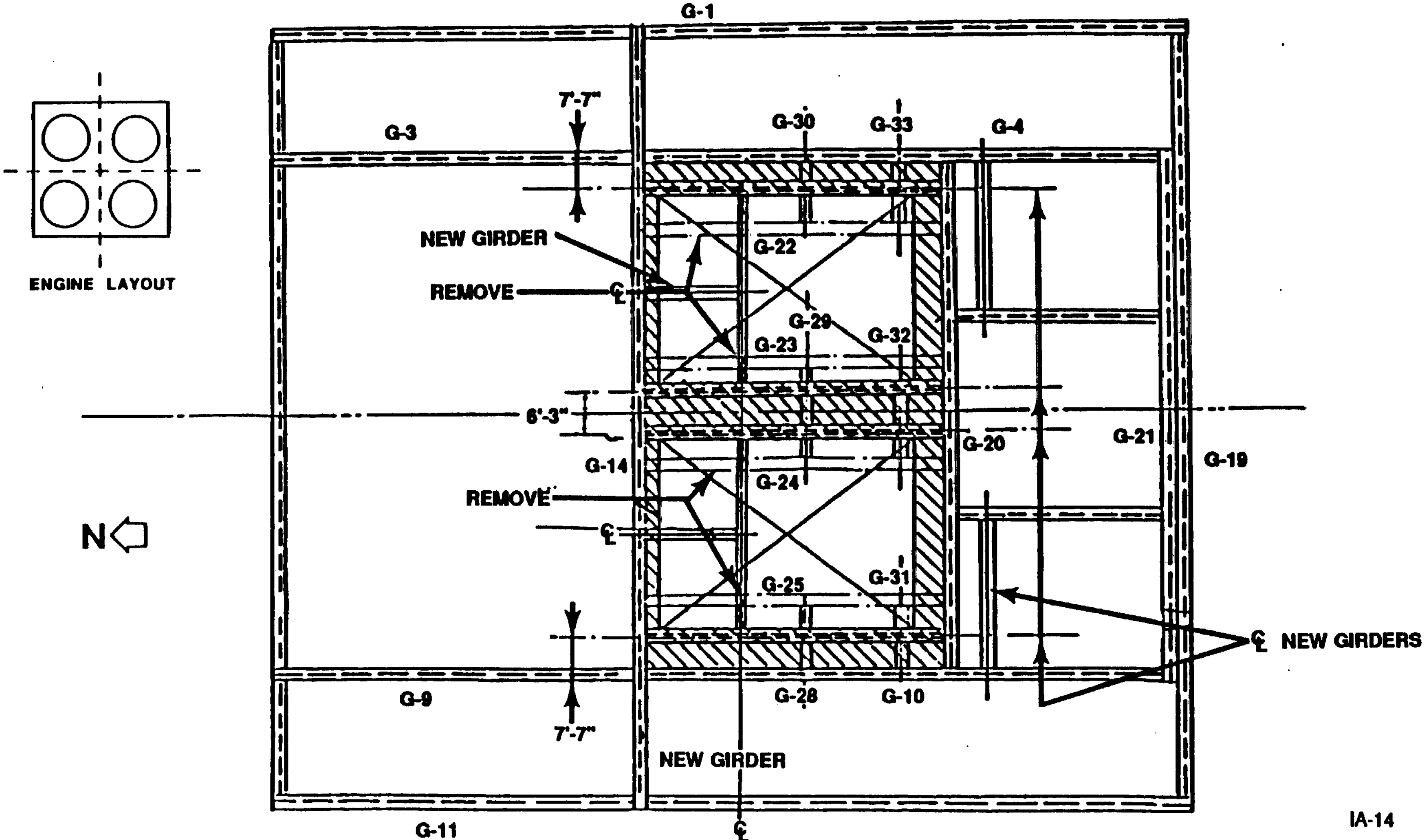
- MLP EXHAUST HOLE MODIFICATION
- GDSS PUMP FED LO2 / RP1
- COMPARISON FOR OTHER GDSS LRB BOOSTERS
- MMC PUMP FED LO2 / RP1
- COMPARISON FOR MMC PRESS FED LO2 / RP1
- HOLD DOWN CONCEPTS

MLP EXHAUST HOLE MODIFICATION (GDSS)

GDSS PUMP-FED LO2/RP1

THE EXISTING MLP REQUIRES MAJOR MODIFICATION OF THE BOOSTER EXHAUST HOLES. NEW GIRDERS ARE REQUIRED TO SUPPORT THE HOLDDOWN SYSTEM ON THE NORTHSIDE. THE EXHAUST HOLES FOR ALL CONFIGURATIONS ARE TO BE ENLARGED TO 4 1'4 1/2" x 27'6 1/4". THERE ARE SOME CONCERNS ON DESIGN FEASIBILITY OF GIRDERS PLACED IN THE EXHAUST HOLES. THESE GIRDERS WOULD REQUIRE EXTENSIVE BLAST PROTECTION AND IN CASE OF "IGNITION AND NO-GO" MAY REQUIRE MAJOR REFURBISHMENT. ENGINE GIMBAL ANGLES OF ±6 DEGREES CAN BE ACCOMMODATED IN THE REDESIGN.

MLP EXHAUST HOLE MODIFICATIONS (GDSS)



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GDSS PUMP-FED LO2/RP1

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LIQUID ROCKET BOOSTER INTEGRATION
FIRST PROGRESS REVIEW

MODIFICATIONS TO MLP FOR GDSS LRB CONCEPTS

	LO2/RP-1 PUMP FED	LO2/RP-1 PRESS FED	LO2 / LH2	LO2 / CH4
BOOSTER DIA	14'-1"	15'-0"	16'-2"	15'-0"
SKIRT DIA	25'-11 1/8"	26'-9 1/2"	22'-3 1/2"	27'-3 1/4"
℄ LRB FROM ℄ ET	21'-10"	22'-3 1/2"	22'-10 1/2"	22'-3 1/2"
EXHAUST HOLE SIZE	41'-4 1/2" X 27'-6 1/4"	SAME	SAME	SAME
IMPACT TO GIRDER G-20	NONE	NONE	NONE	NONE
℄ ET TO RELOCATED G-23 AND G-24	6'-3"	6'-8 1/2"	8'-3 1/2"	6'-8 1/2"
℄ G-10 TO RELOCATED G-25 AND G-4 TO RELOCATED G-22	7'-7"	7'-1 1/2"	5'-6 1/2"	7'-1 1/2"
LOCATION OF NEW GIRDER TO SUPPORT RELEASE MECH FROM ℄ LRB	15'-7"	15'-7"	15'-7"	15'-7"
HAUNCH SIZE & SUPPORTS	TBD	TBD	TBD	TBD

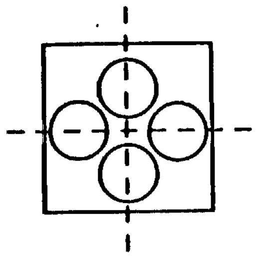
MLP EXHAUST HOLE MODIFICATION (MMC)

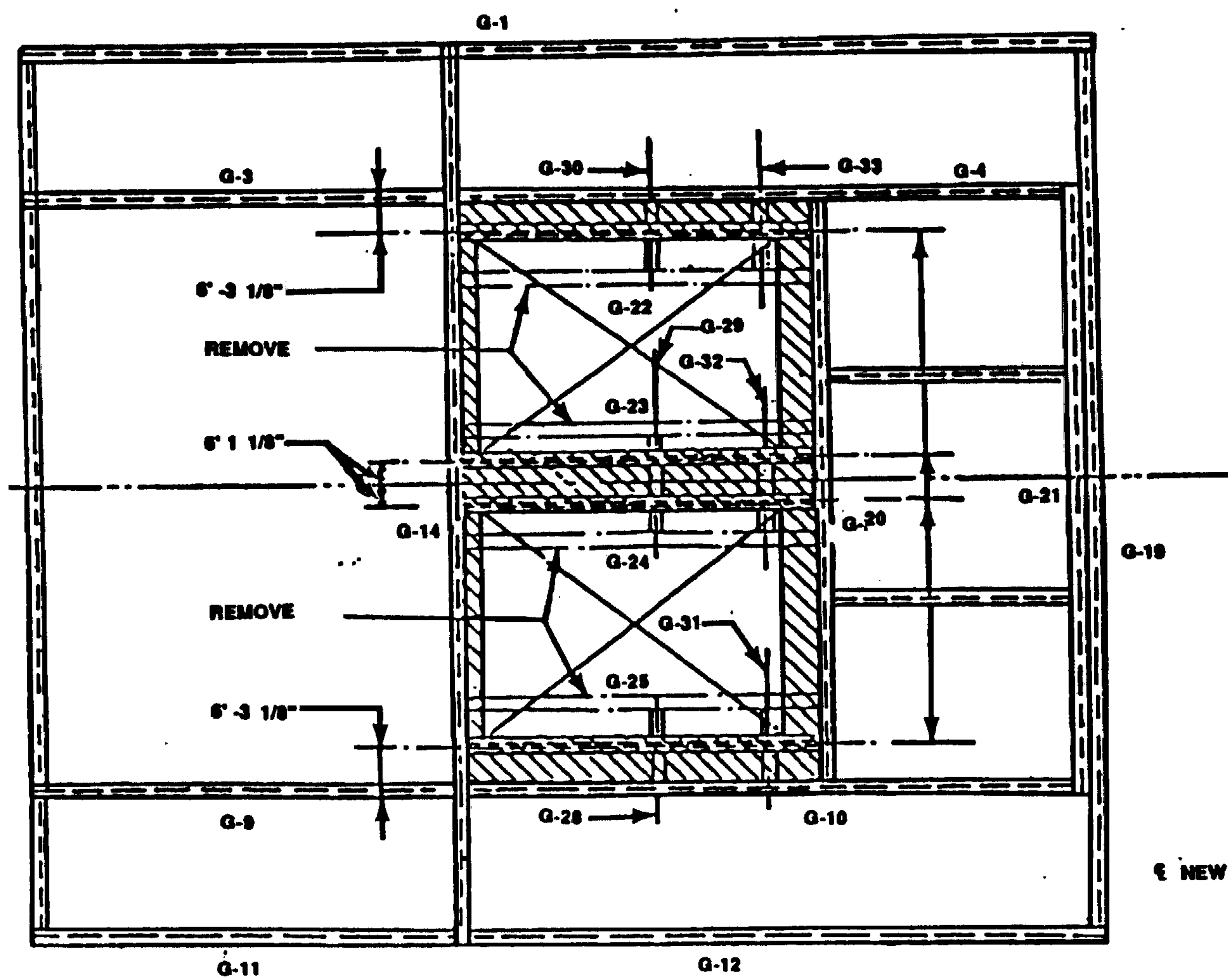
<u>MARTIN MARIETTA PUMP-FED LOX/RP1</u>

THE EXISTING MLP EXHAUST HOLES WILL BE ENLARGED FOR LRB EXHAUST. (41'-4½" x 29' 0"). NEW GIRDERS WILL BE INSTALLED REPLACING GIRDERS G-22,23,24 & 25. RECONFIGURATION OF THE BLAST SHIELD STRUCTURE WILL BE REQUIRED. A MAJOR CONSTRAINT FOR REDESIGN OF AN EXISTING MLP IS <u>NO CHANGE IN LOCATION OF THE G-20</u> GIRDER BECAUSE OF MLP STRUCTURAL INTEGRITY AND SSME EXHAUST HOLE INFRINGEMENT.

ENGINE GIMBAL ANGLES OF ±6° PRESENT NO PROBLEM FOR STRUCTURAL CLEARANCE FOR THE PUMP FED CONFIGURATION. THE MINIMUM CLEARANCE IS APPROXIMATELY 2'-0". THE G20 GIRDER IS IMPACTED BY THE PRESSURE FED CONFIGURATION.

MLP EXHAUST HOLE MODIFICATIONS (MMC)





℄ NEW GIRDERS

MMC PUMP-FED LOX / RP-1

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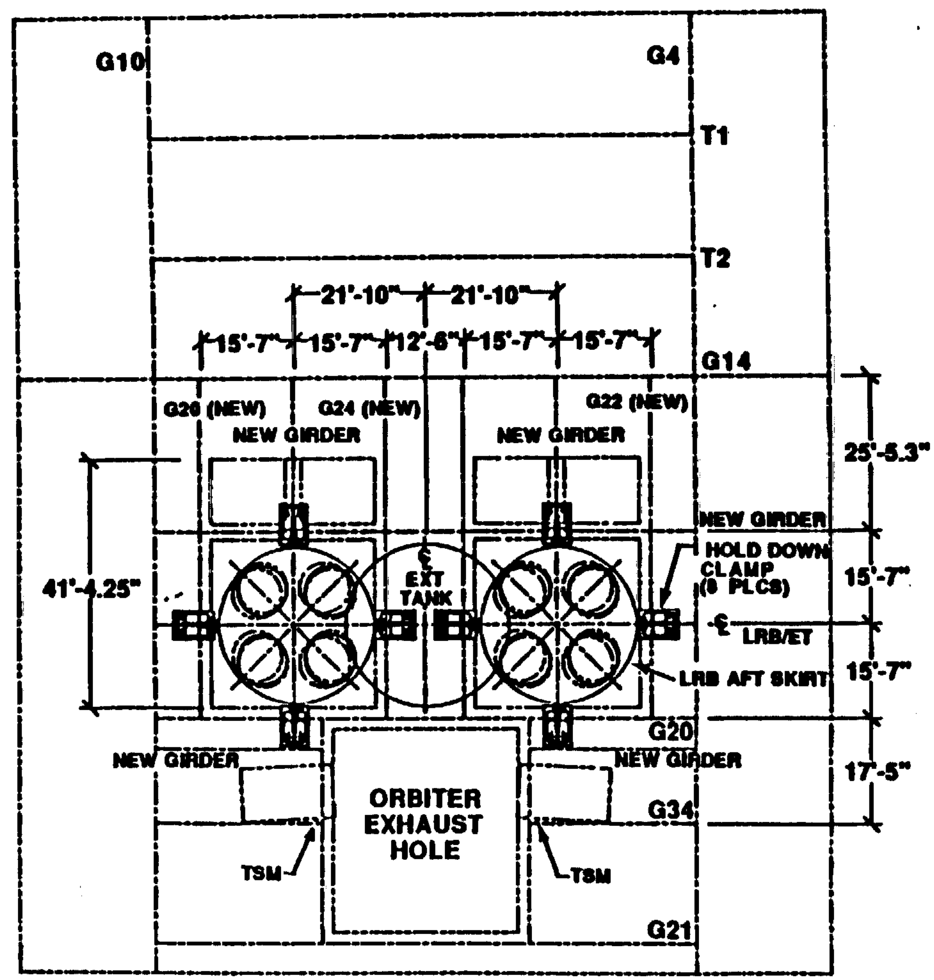
MODIFICATIONS TO MLP FOR MARTIN LRB CONCEPTS

	LO2/RP-1 PUMP FED	LO2/RP-1 PRESS FED
BOOSTER DIA	15'-3"	16'-2"
SKIRT DIA	22'-1 1/4"	26'-0"
℄ LRB FROM ℄ ET	22'-5"	22'-9 1/2"
EXHAUST HOLE SIZE	29'-0" X 41'-4 1/4"	32'-0" X TBD
IMPACT TO G-20 AT 6° ENGINE GIMBLE	APPROX 2' CLEARANCE FROM BLAST SHIELD	RELOCATE
℄ G-10 TO RELOCATED G-25 AND G-4 TO RELOCATED G-2	6'-3 1/8"	3'-4 5/8"
℄ ET TO RELOCATED G-23 & G-24	6'-1 1/8"	4'-11 5/8"
LOCATION OF NEW HOLDDOWN POST HAUNCHES	TBD	TBD

HOLD DOWN MECHANISM (GDSS) LAYOUT

A CONCEPTUAL LAYOUT FOR HOLD DOWN MECHANISMS LOCATES THE HOLD DOWN POINTS ON THE CENTERLINE AXIS OF THE LRB ON THE ZERO DECK OF THE MLP. DESIGN ANALYSIS FOR SIZE AND LOADS IS REQUIRED. THIS ANALYSIS WILL REQUIRE THE DRIFT PROJECTIONS, FINAL WEIGHT OF LRB AND SKIRT DETAILS. THE GIRDER WHICH CROSSES THE EXHAUST HOLE WILL BE LOCATED BASED ON DRIFT PROJECTIONS WHEN AVAILABLE.

HOLD DOWN MECHANISM (GDSS) LAYOUT



PLAN - MLP GDSS LO2/RP-1 PUMP FED LRB

HOLD DOWN MECHANISM (GDSS)

SOFT RELEASE CONCEPT

THE HOLD DOWN DEVICE DESIGN IS SIMILAR TO THE HOLD DOWN SYSTEM USED ON SATURN V. THE RELEASE SYSTEM WILL CONSIST OF THE FOLLOWING MAJOR COMPONENTS:

1. HOLD DOWN HOUSING
2. HOLD DOWN ARM
3. AFT SKIRT SHOE
4. COUNTERWEIGHT/DIE
5. HOLD DOWN STUD BOLT & PYRO-NUT
6. EXTRUSION PINS AND NUT

THE HOLD DOWN CLAMPING FORCE WILL BE PROVIDED BY THE STUD BOLT & PYRO-NUT THRU THE COUNTERWEIGHT DIE AND THE HOLD DOWN ARM TO THE LRB AFT SKIRT SUPPORT COLUMN. AT T-0 SECONDS THE PYRO-NUT IS EXPLODED AND ALL LIFT-OFF FORCES ARE TRANSFERRED FROM THE AFT SKIRT VIA THE HOLD DOWN ARM TO THE EXTRUSION PINS. AS THE DIE CLEARS THE EXTRUSION, THE HOLD DOWN ARM IS FULLY RETRACTED. THE COUNTERWEIGHT ENSURES THE HOLD DOWN ARM WILL FULLY RETRACT TO CLEAR THE LRB SKIRT. ALL DEBRIS WILL BE CONTAINED INSIDE THE HOUSING.

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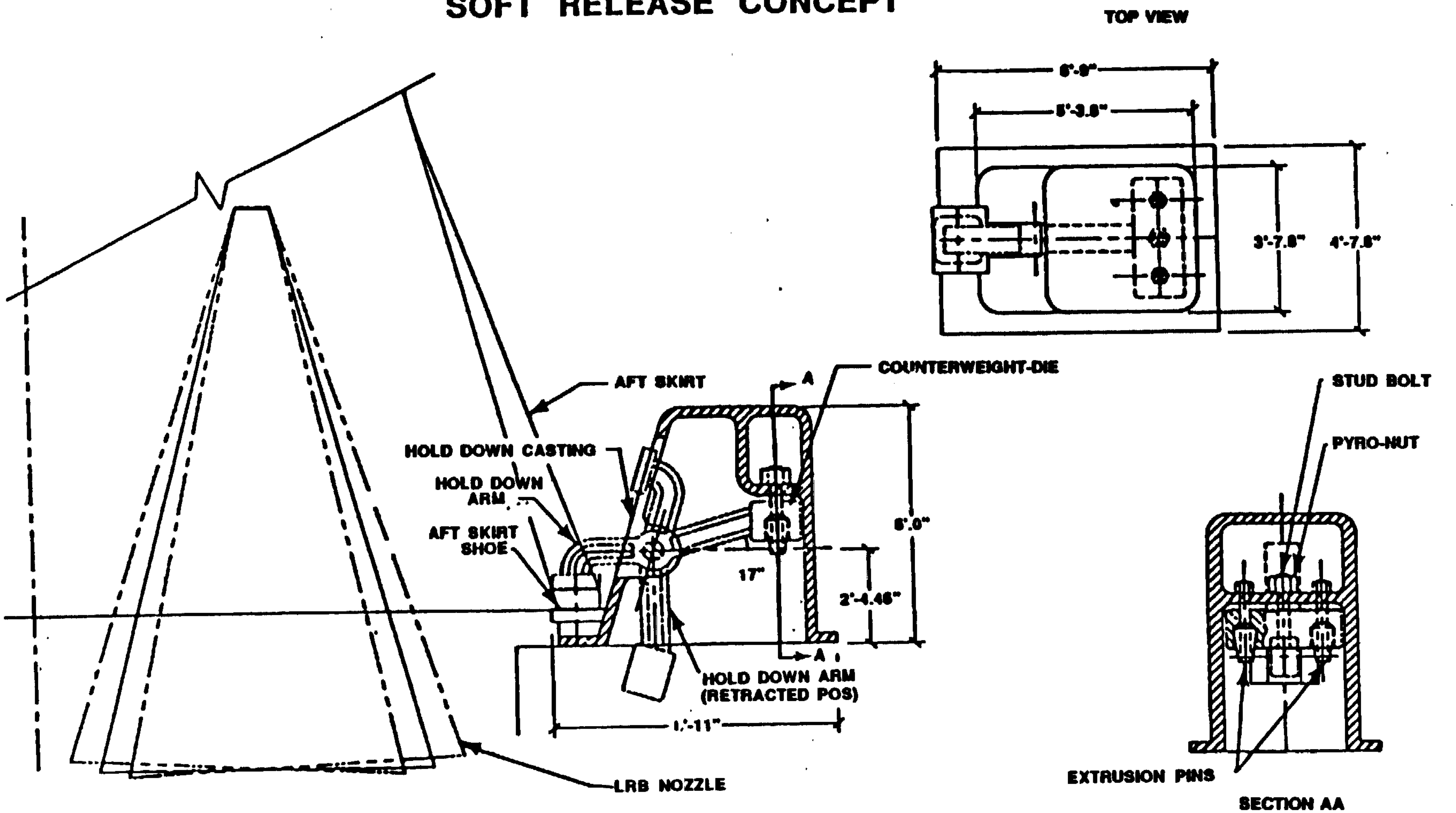
HOLD DOWN MECHANISM (GDSS)

SOFT RELEASE CONCEPT



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HOLD DOWN POST/HAUNCH (MMC) LAYOUT

A CONCEPTUAL LAYOUT, FOR HOLD DOWN POSTS AND HAUNCHES, LOCATES THE HOLD DOWN POINTS 45° TO THE CENTERLINE AXIS OF THE LRB, IN THE MLP EXHAUST HOLE. THIS IS SIMILAR TO THE SRB CONFIGURATION. DESIGN ANALYSIS FOR SIZE AND LOADS IS REQUIRED. THIS ANALYSIS WILL REQUIRE THE DRIFT PROJECTIONS, FINAL WEIGHT OF LRB AND SKIRT DETAILS.

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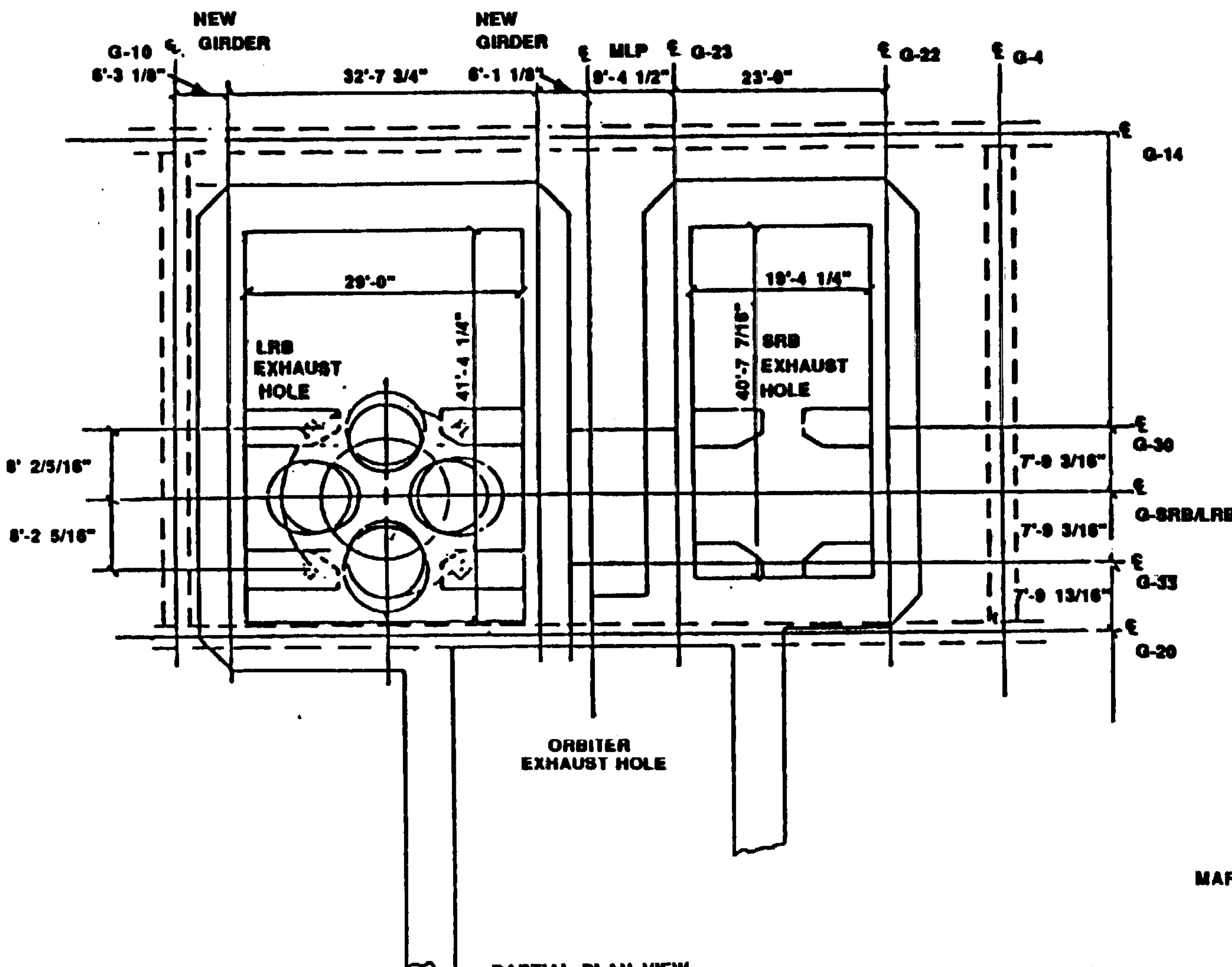
HOLD DOWN POST / HAUNCH (MCC) LAYOUT



PARTIAL PLAN VIEW

MARTIN PUMP-FED LO2/RP1

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HOLD DOWN POST WITH SOFT RELEASE (MMC)

THE SOFT RELEASE SYSTEM CONCEPT USED ON APOLLO WITH THE HOLD DOWN SYSTEM USED PRESENTLY WAS CHOSEN FOR THIS STUDY. IN THIS ARRANGEMENT A PRE-SHAPED BILLET OF MALLEABLE MATERIAL HAS A DIE EXTRUDED THROUGH IT TO PROVIDE A SLOW, DAMPED RELEASE OF THE LRB.

1. THE TENSIONING OF THE HOLD DOWN STUD WILL BE THE SAME PROCEDURE FOR SRB'S
2. PLACE THE LOWER RETAINER OVER THE PYRO-NUT
3. ATTACH THE LOWER RETAINER TO THE LRB FOOT
4. PLACE THE BILLET ON TOP OF THE LOWER RETAINER
5. THREAD THE DIE TO THE HOLD DOWN STUD
6. ATTACH THE UPPER RETAINER TO THE LOWER RETAINER

AT LAUNCH THE RESTRAINT FORCE IS RELEASED FROM THE PYRO-NUT AND THE LOAD PATH PROCEEDS FROM THE HOLD DOWN STUD TO THE DIE, FROM THE DIE TO THE BILLET WHICH IN TURN RESTS ON THE LOWER RESTRAINT AND FINALLY TO THE LRB FOOT. AT THIS POINT THE ASCENDING STS CAUSES THE DIE TO BE EXTRUDED THROUGH THE BILLET THUS PROVIDING A SOFT RELEASE. AFTER THE EXTRUSION PROCESS THE HOLD DOWN STUD, WITH THE ATTACHED DIE, FALLS THROUGH INTO THE HOLLOW OF THE HOLD DOWN POST WHILE THE PYRO-NUT AND THE OTHER ELEMENTS ABOVE IT ARE CAPTURED BETWEEN THE UPPER AND LOWER RESTRAINT HOUSING.

LIQUID ROCKET BOOSTER INTEGRATION FIRST PROGRESS REVIEW

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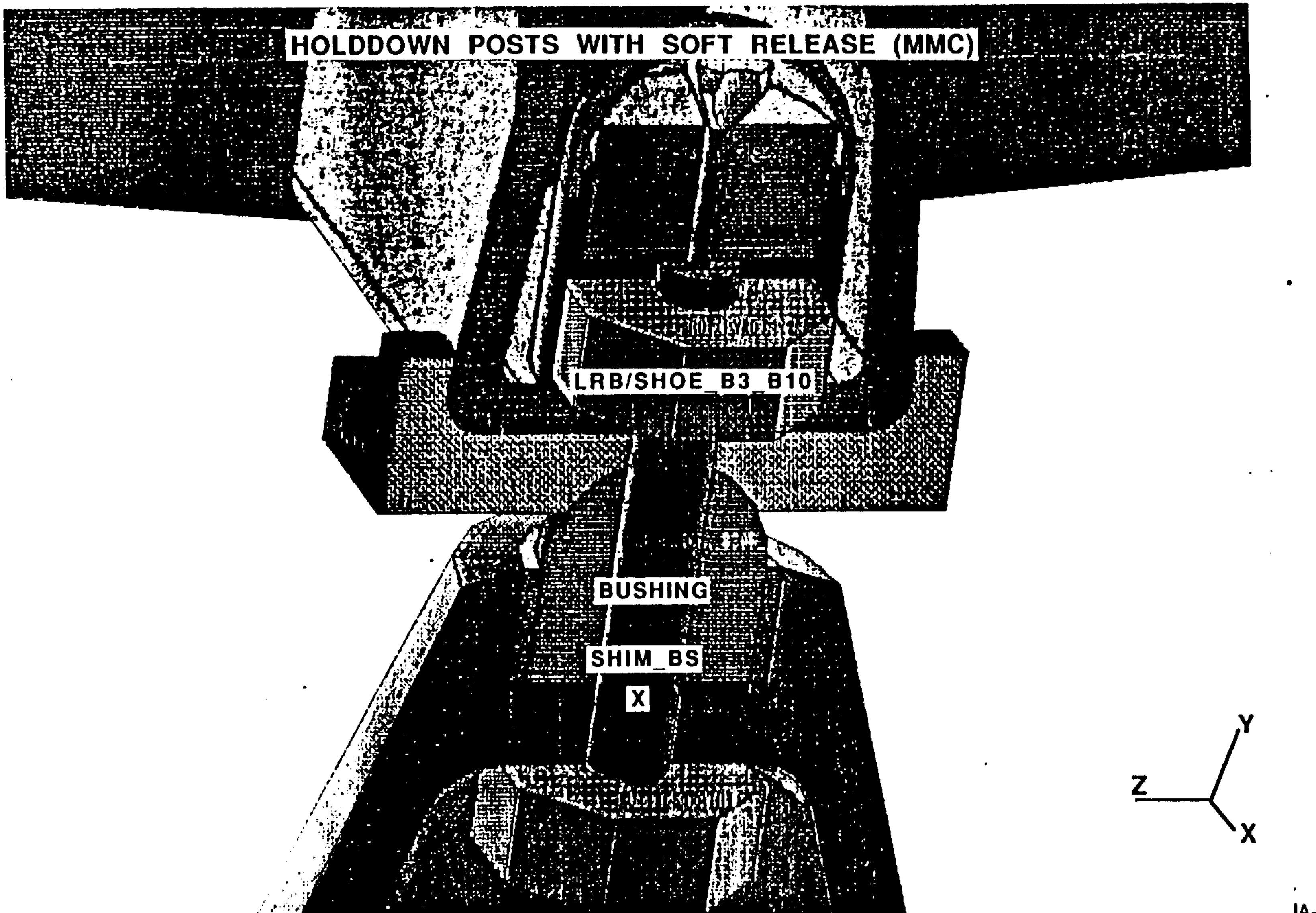

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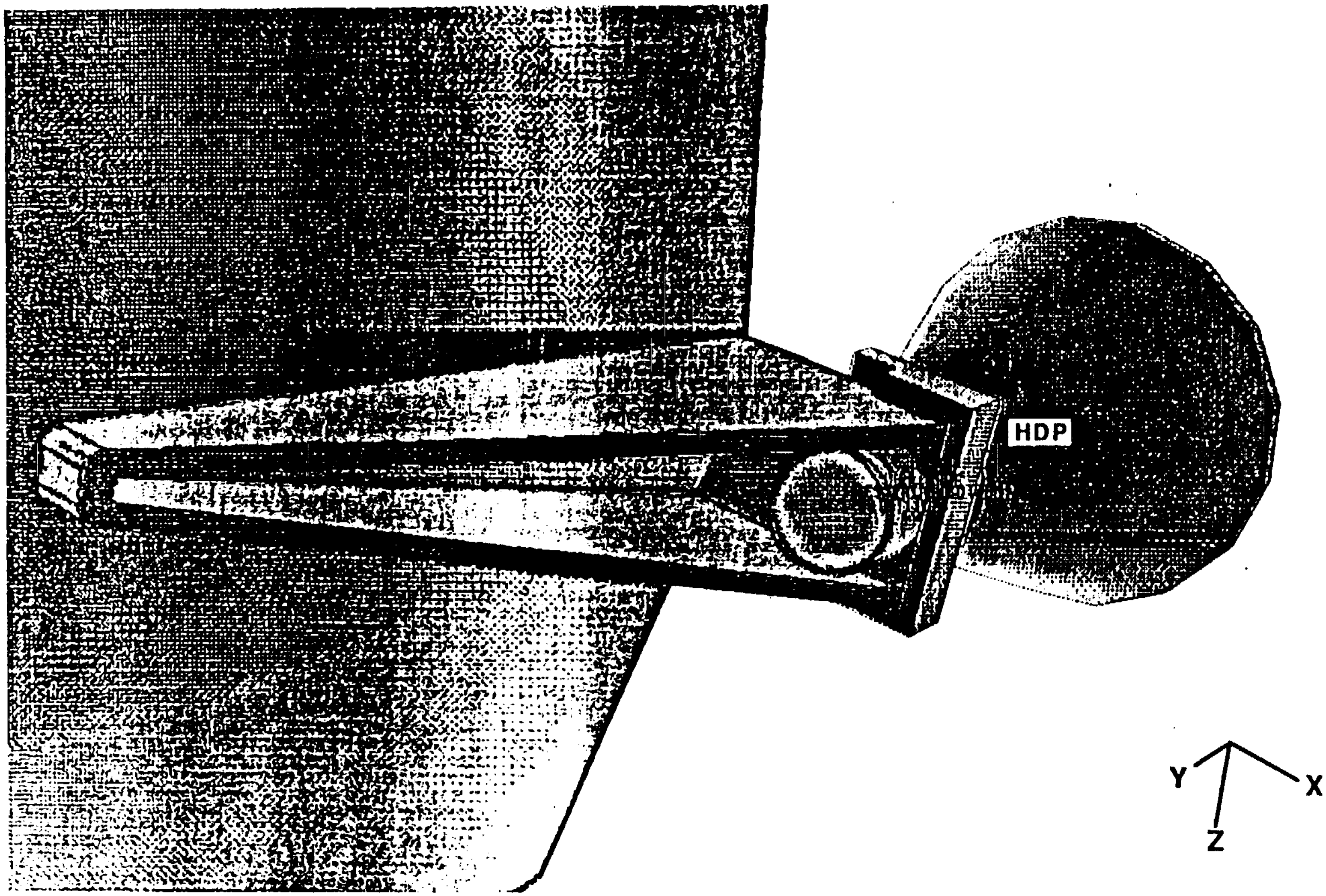
HOLDDOWN POSTS WITH SOFT RELEASE (MMC)



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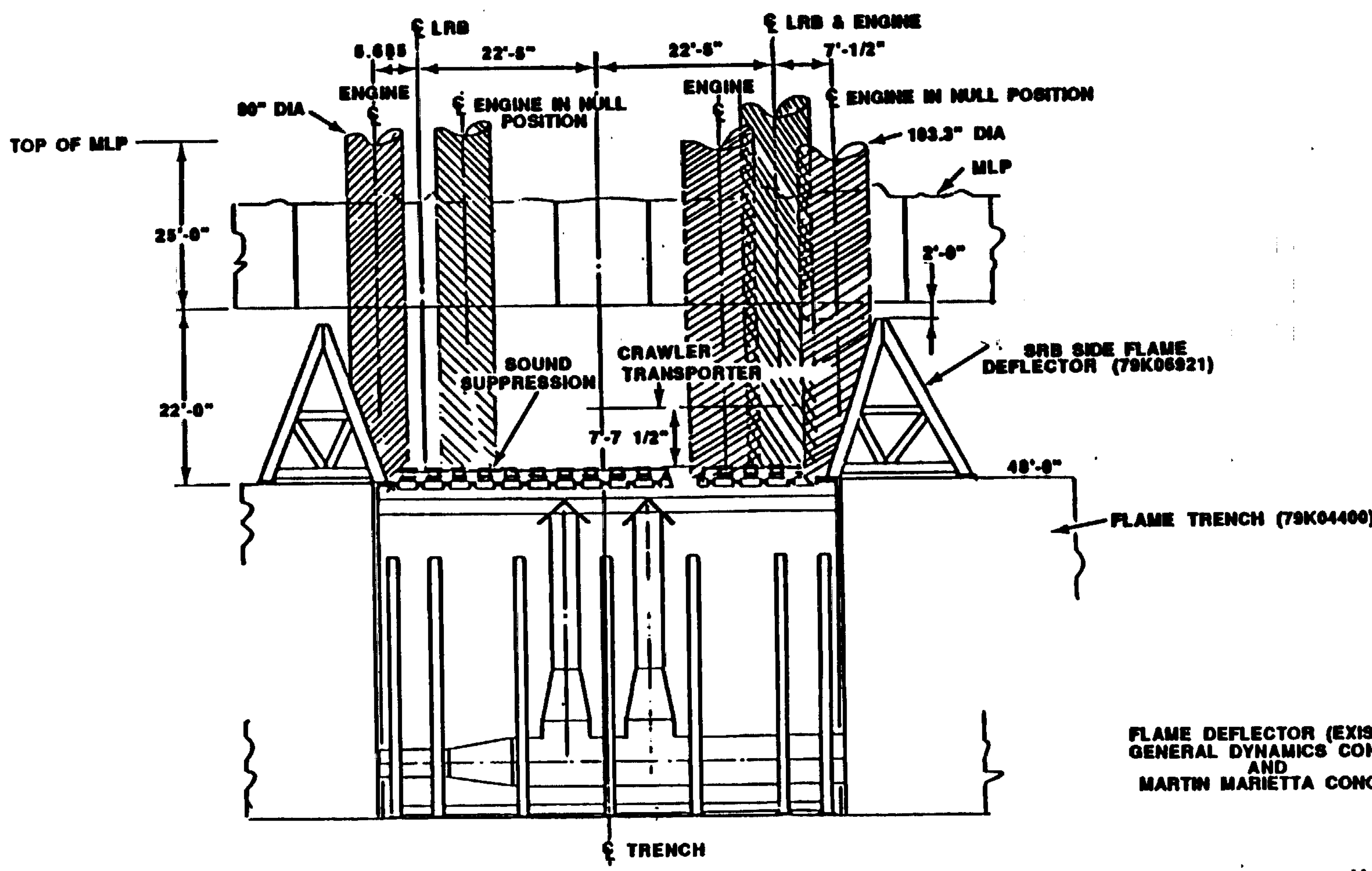
LAUNCH PAD

- FLAME DEFLECTORS
- PAD UMBILICAL SYSTEMS
  - GOX VENT
  - ET H2 VENT
- LRB UMBILICAL SYSTEMS
- LAUNCH PAD ACCESS PLATFORMS
- WEATHER PROTECTION SYSTEM

PAD FLAME DEFLECTORS

EVALUATION OF THE EXISTING MAIN FLAME DEFLECTOR AND THE SIDE FLAME DEFLECTORS WITH THE PROPOSED GENERAL DYNAMICS AND MARTIN MARIETTA CONCEPTS EXPOSED MAJOR PROBLEMS WITH THE PRESENT SYSTEM. WITH THE INTRODUCTION OF FOUR ENGINE EXHAUSTS PER LRB THE BLAST PRESSURE HAS BEEN SHIFTED SOUTH ON THE MAIN FLAME DEFLECTOR AND EAST AND WEST ON THE SIDE FLAME DEFLECTORS. THIS WILL INTRODUCE DIRECT BLAST ON THE SOUND SUPPRESSION SYSTEM ON THE TOP OF THE MAIN FLAME DEFLECTOR WITH THE ENGINE IN THE NULL POSITION, WHICH INCREASES IF THE ENGINES GIMBAL SOUTH. IT ALSO INTRODUCES DIRECT BLAST PRESSURES ON THE SIDE FLAME DEFLECTORS, WHICH INCREASES IF THE ENGINES GIMBAL EAST AND WEST.

PAD FLAME DEFLECTORS



FLAME DEFLECTOR (EXISTING)
GENERAL DYNAMICS CONCEPT
AND
MARTIN MARIETTA CONCEPT

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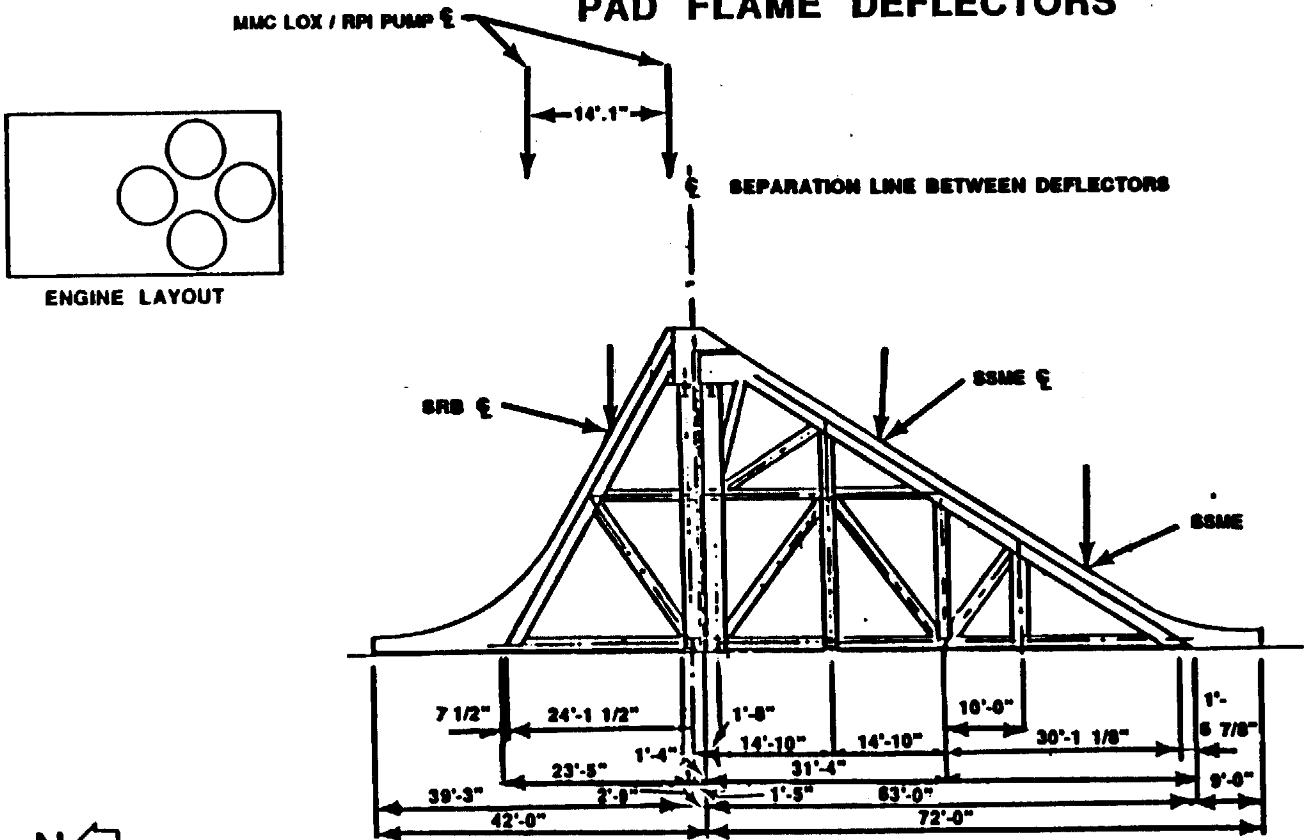
PAD FLAME DEFLECTORS

MAJOR MODIFICATIONS ARE REQUIRED TO THE MAIN FLAME DEFLECTOR FOR BOTH THE SRB AND THE SSME SIDES. THIS WILL INVOLVE SHIFTING THE SEPARATION LINE BETWEEN THE FLAME DEFLECTORS SOUTH TO ACCOMMODATE THE NEW CONFIGURATION. SIMILARLY MAJOR MODIFICATIONS ARE REQUIRED TO THE SIDE FLAME DEFLECTORS. THIS WILL INVOLVE HAVING THE CAPABILITY OF EFFECTIVELY DIRECT THE BLAST PRESSURE TO THE FLAME TRENCH AND THE STRENGTH TO WITHSTAND THE DIRECT BLAST PRESSURE. IN ADDITION TO THAT, AN EVALUATION OF THE FOUNDATIONS FOR THE SIDE FLAME DEFLECTORS IS REQUIRED TO DETERMINE THEIR CAPACITIES FOR THE NEW LOADS.

PAD FLAME DEFLECTORS



IMPINGEMENT LOADS
ON EXISTING FLAME DEFLECTOR

FLAME DEFLECTOR
MARTIN MARIETTA CONCEPT

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PAD UMBILICAL SYSTEMS

THE UMBILICALS REVIEWED FOR IMPACT INCLUDE THE GOX VENT, OMBUU, OAA, HYPERGOL UMB(S), ET H_2 VENT AND TSM(S).

THE GOX VENT IS AFFECTED BY THE HEIGHT OF THE GDSS LO_2/LH_2 AND GDSS LO_2/RP1 PRESSURE-FED CONFIGURATIONS. EITHER ONE WILL REQUIRE EXTENSIVE MODIFICATION AND CONCEPT CHANGE FOR THE ARM.

THE ET H_2 VENT IS EFFECTED BY ALL LRB CONFIGURATIONS. EXTENSIVE MODIFICATION, RELOCATION AND CONCEPT CHANGES WILL BE REQUIRED.

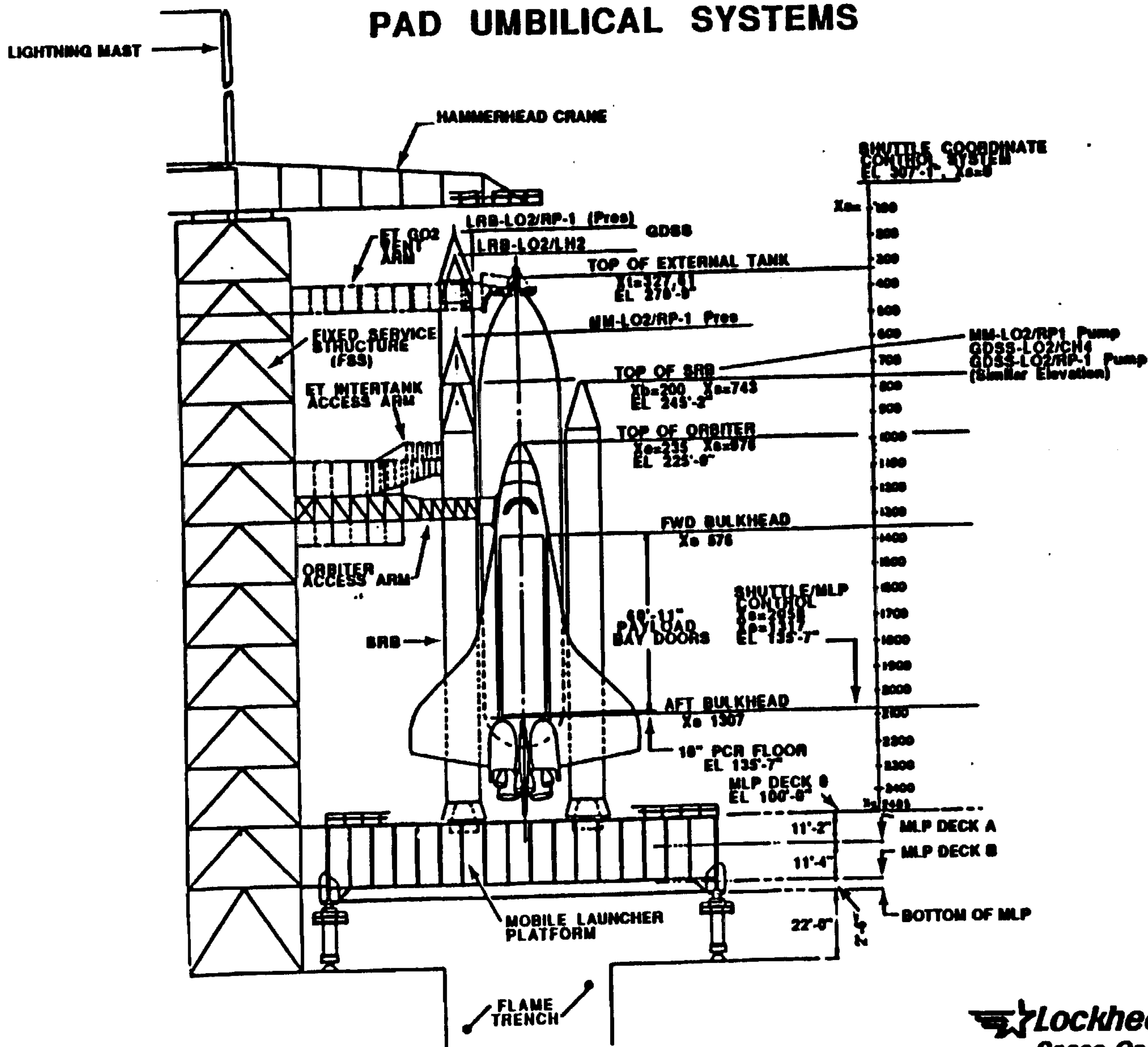
THE OMBUU, OAA & HYPERGOL UMB HAVE NO IMPACT BY THE LRB.

THE TSM WILL BE UNEFFECTED BASED ON THE ASSUMPTION THAT VEHICLE EXCURSIONS REMAIN UNCHANGED.

IF EXCURSIONS AND DRIFTS ARE AFFECTED THE TSM(S), OMBUU AND OAA WILL REQUIRE ADJUSTMENT. SINCE THE OAA AND ET VENT HAVE LIMITED EXCURSION CAPABILITY THE IMPACT WILL BE EXTENSIVE.

ALL CHANGED/MODIFIED UMBILICAL SYSTEMS WILL REQUIRE RE-QUALIFICATION AND ACCEPTANCE TESTING AT THE LETF.

PAD UMBILICAL SYSTEMS



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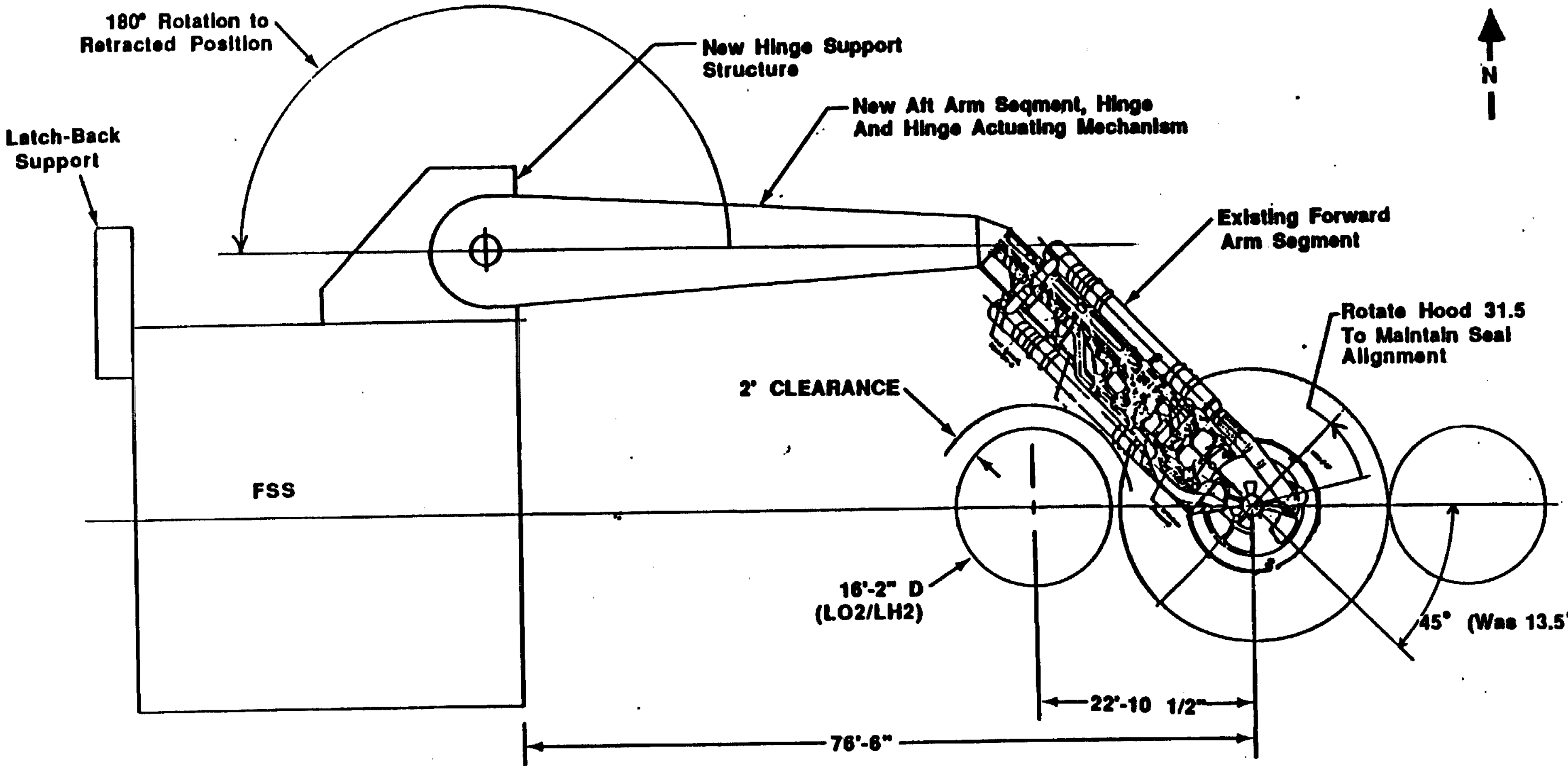
GOX VENT

THIS UMBILICAL IS UNAFFECTED BY THE DIAMETER INCREASES FOR ANY OF THE SIX (6) LRB CONCEPTS, HOWEVER; LRB LENGTHS OVER 170 FEET HAVE HARD INTERFERENCE WITH THE EXISTING STRUCTURE. THE GDSS LO2/RP-1 (PRES) AND LO2/LH2 ARE INCOMPATIBLE WITH THE CURRENT GOX VENT. TO PROVIDE GOX VENTING CAPABILITY WITH THESE LRB'S WOULD REQUIRE EXTENSIVE MODIFICATION TO THE UMBILICAL.

THIS CONCEPT USES AS MUCH OF THE EXISTING ARM AND ASSOCIATED COMPONENTS AS POSSIBLE, BUT REQUIRES A NEW OR MODIFIED HOOD ASSEMBLY, A NEW AFT ARM SEGMENT, NEW HINGE AND HINGE ACTUATING MECHANISM, AND STRUCTURAL ADDITIONS TO THE FIXED SERVICE STRUCTURE (FSS). ADDITIONALLY, A MODIFICATION OF THIS MAGNITUDE WILL REQUIRE LETF REQUALIFICATION AND VALIDATION TESTING.

GOX VENT



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GO2 VENT FOR GDSS LO2 / LH2 OR GDSS LO2 / RP-1 (PRES)

80708-01X13

ET H2 VENT

THE MOST SIGNIFICANT CONCERN DEALS WITH VEHICLE DRIFT CLEARANCE TO THE ET VENT SUPPORT STRUCTURE. THE SRB DRIFT PATH PAST THE ET VENT OCCURS AS THE SKIRT PASSES THE 222'6.½" LEVEL.

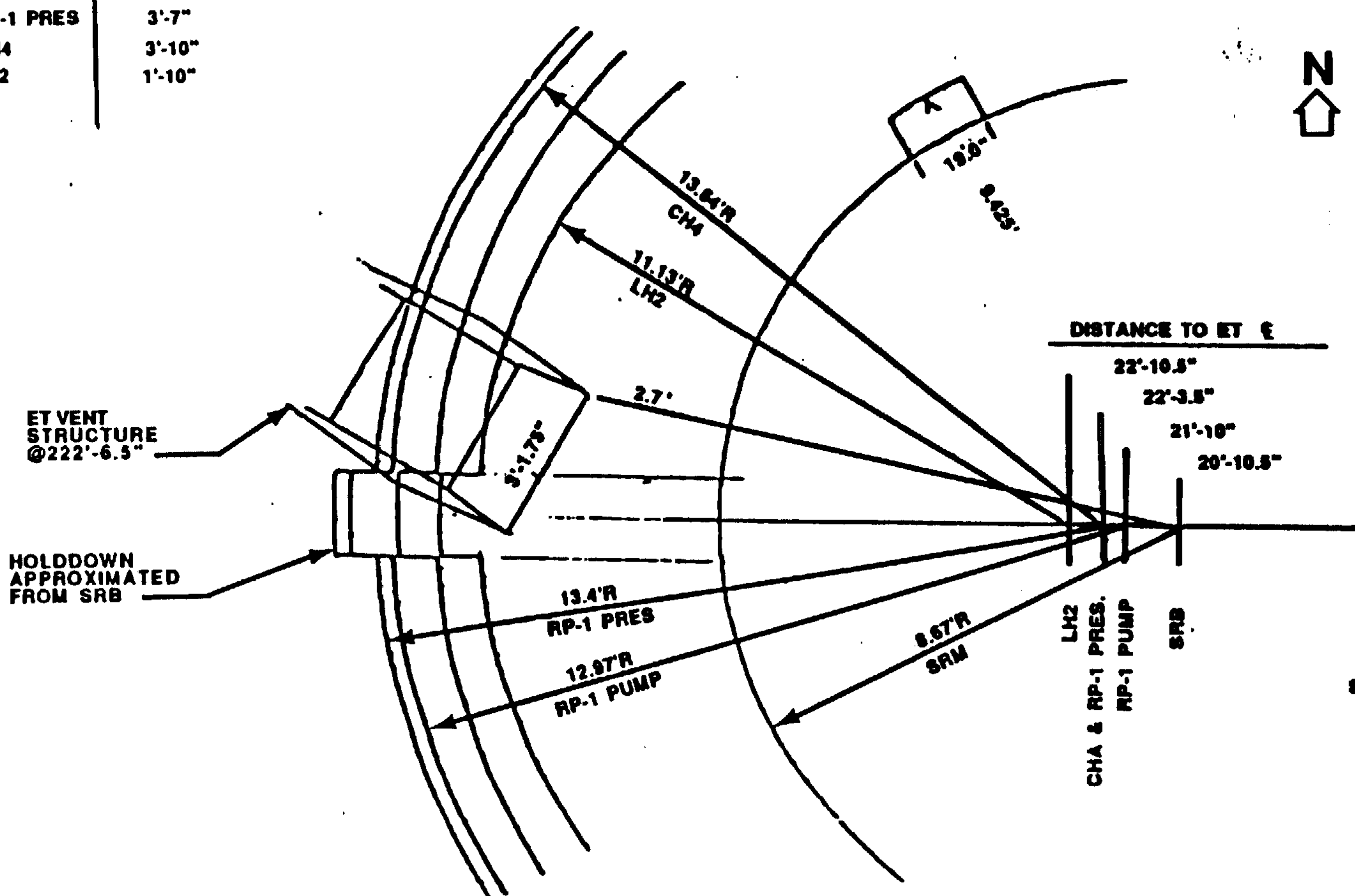
THE MINIMUM CLEARANCE IS 2.7 FEET. ASSUMING A SIMILAR DRIFT FOR THE LRB'S AND USING THE LARGER SKIRT DIAMETER, THE STRUCTURE TO VEHICLE RELATIONSHIP IS SHOWN.

ALL THE LRB CONFIGURATIONS SHOW INTERFERENCE AT THE 222'6½" LEVEL.

ET H2 VENT
LRB(GDSS)* SKIRT TO ET VENT ARM DRIFT STUDY

LRB	INTERFERENCE
RP-1 PUMP	2'-9"
RP-1 PRES	3'-7"
CH4	3'-10"
LH2	1'-10"

USING WORST WEST DRIFT FOR SRB (ENG. NO 2 OUT) @ 222'-6 1/2"



SCALE: 3/8"=1'

*MM RP-1 PUMP AND PRES HAVE SIMILAR INTERFERENCES

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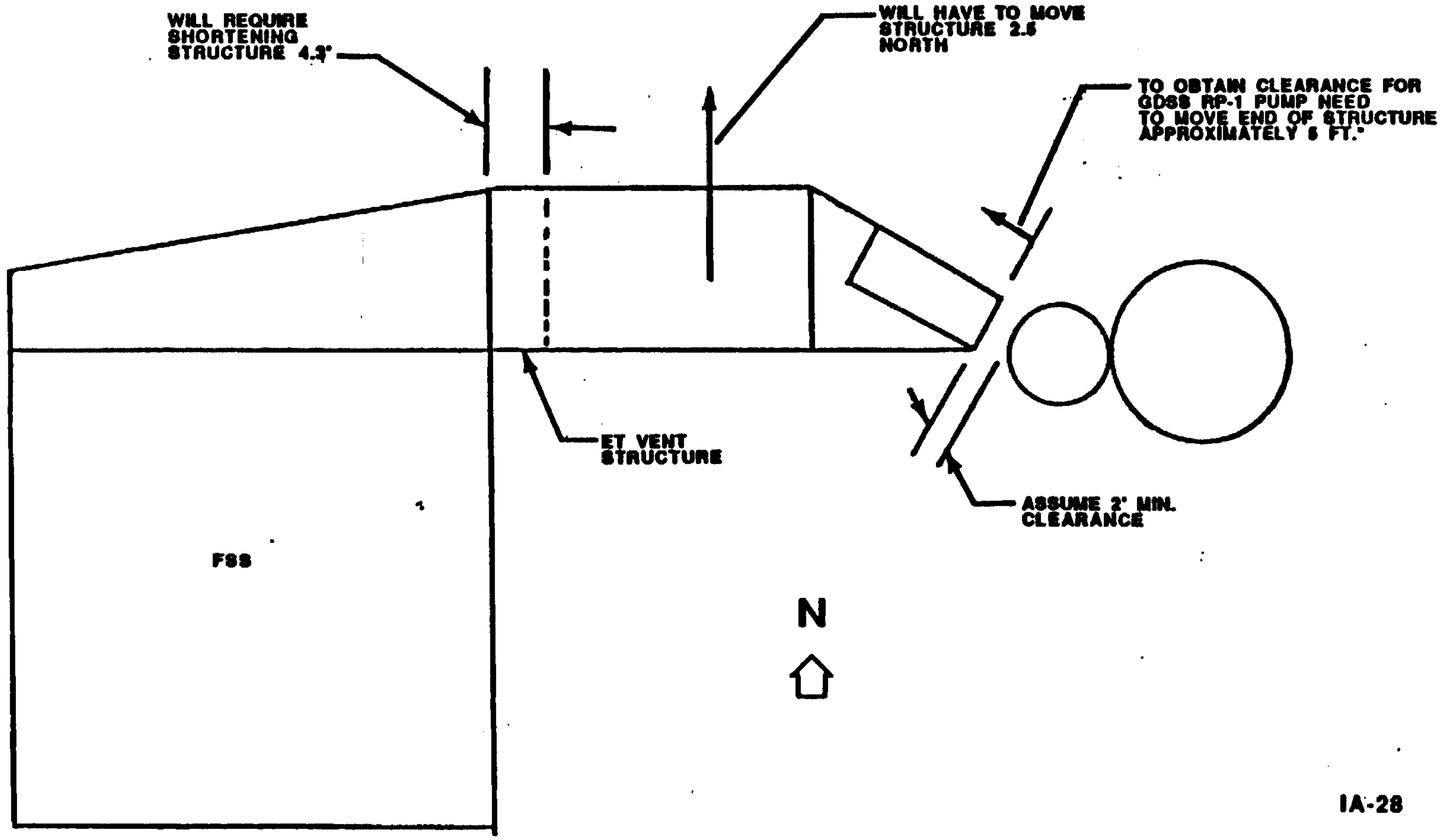
ET H2 VENT

THIS FIGURE SHOWS THE REQUIRED RELOCATION OF THE ET VENT STRUCTURE TO OBTAIN A TWO (2) FOOT CLEARANCE FOR THE GDSS LO2/RP-1 PUMP CONFIGURATION.

RELOCATING THE STRUCTURE WILL NECESSITATE LENGTHENING THE VENT LINE BY APPROXIMATELY FIVE (5) FEET, THIS IS TURN WILL MAKE IT NECESSARY TO MODIFY THE LOWER LEVEL OF ET VENT STRUCTURE AND DECEL UNIT SINCE THE VENT LINE WILL EXTEND LOWER WHILE IN THE RETRACTED POSITION.

LENGTHENING THE VENT LINE WILL AGGRAVATE THE ALREADY MARGINAL PYRO BOLT LOAD FOR THE ET VENT GROUND UMBILICAL CARRIER PLATE. TO PROVIDE ADEQUATE VEHICLE DRIFT CLEARANCE TO THE ET VENT WILL REQUIRE EXTENSIVE MODIFICATION OF THE UMBILICAL, AND COMPLETE LETF REQUALIFICATION & VALIDATION TESTING.

ET H2 VENT
ET VENT STRUCTURE RELOCATION FOR LRB DRIFT CLEARANCE



*ALL THE LRB CONCEPTS REQUIRE RELOCATION OF ET VENT STRUCTURE (ASSUMING SRB DRIFTS).

- WORST CASE GDSS LO2/CH4 = 6 FT. RELOCATION
- BEST CASE GDSS LO2/LH2 4 FT. RELOCATION

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LRB UMBILICAL SYSTEMS

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- TO ACCOMODATE THE LRB NEW UMBILICAL SYSTEMS WILL BE REQUIRED. THE SYSTEMS WILL REQUIRE QUALIFICATION TESTING AT THE LETF.

LRB / LAUNCH UMBILICAL SYSTEMS SUMMARY

IMPACT \ LRB OPTION	MM LO2 / RP-1 PUMP	MM LO2 / RP-1 PRESSURE	GDSS LO2 / RP-1 PUMP	GDSS LO2 / RP-1 PRESSURE	GDSS LO2 / LH2	GDSS LO2 / CH4
NEW LO2 TSM FOR EACH LRB	X	X	X	X	X	X
NEW LH2 TSM FOR EACH LRB					X	
NEW CH4 TSM FOR EACH LRB						X
NEW GH2 VENT LINE & SWING ARM FOR EACH LRB					X	
NEW CH4 VENT LINE & SWING ARM FOR EACH LRB						X
NEW GH2 VENT LINE TOWER					X	
NEW CH4 VENT LINE TOWER						X
MOD OF ET GH2 VENT LINE / ARM SYS	X	X	X	X	X	X
MOD OF ET GOX VENT ARM AND FSS				X	X	
NEW POWER / INST. FOR EACH LRB	X	X	X	X	X	X

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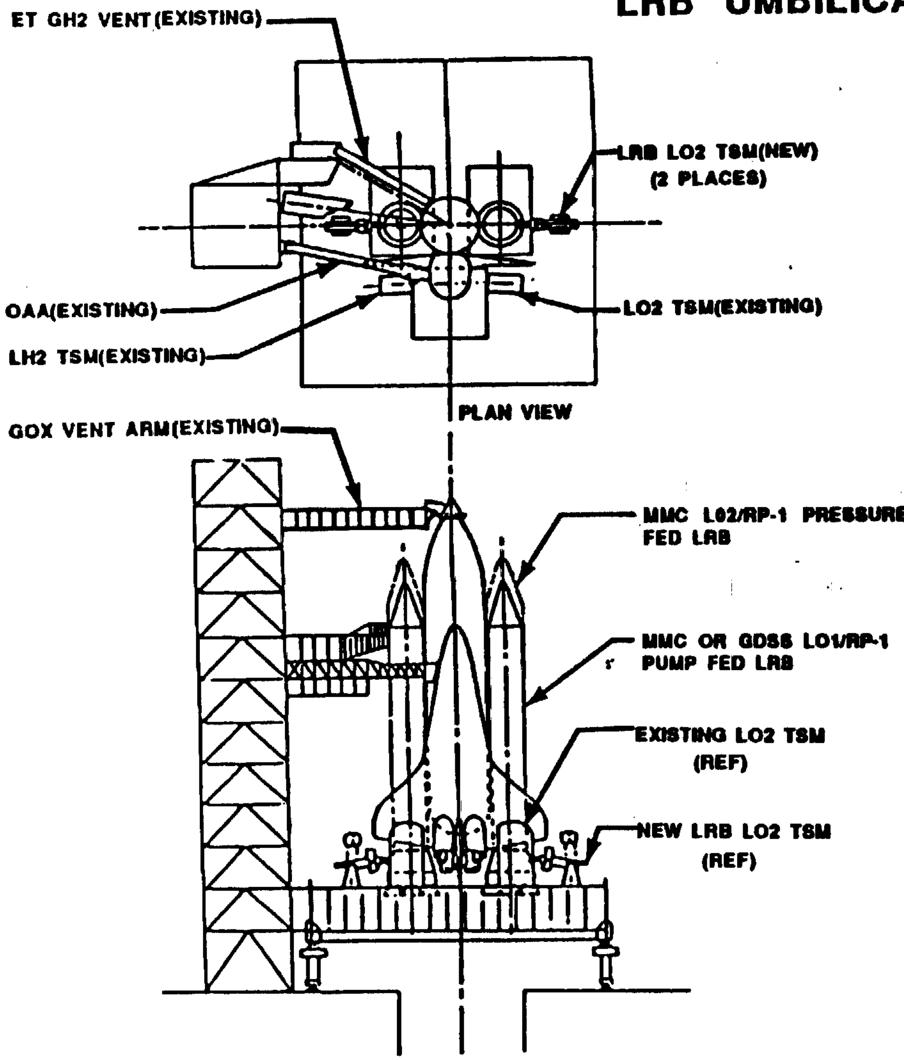
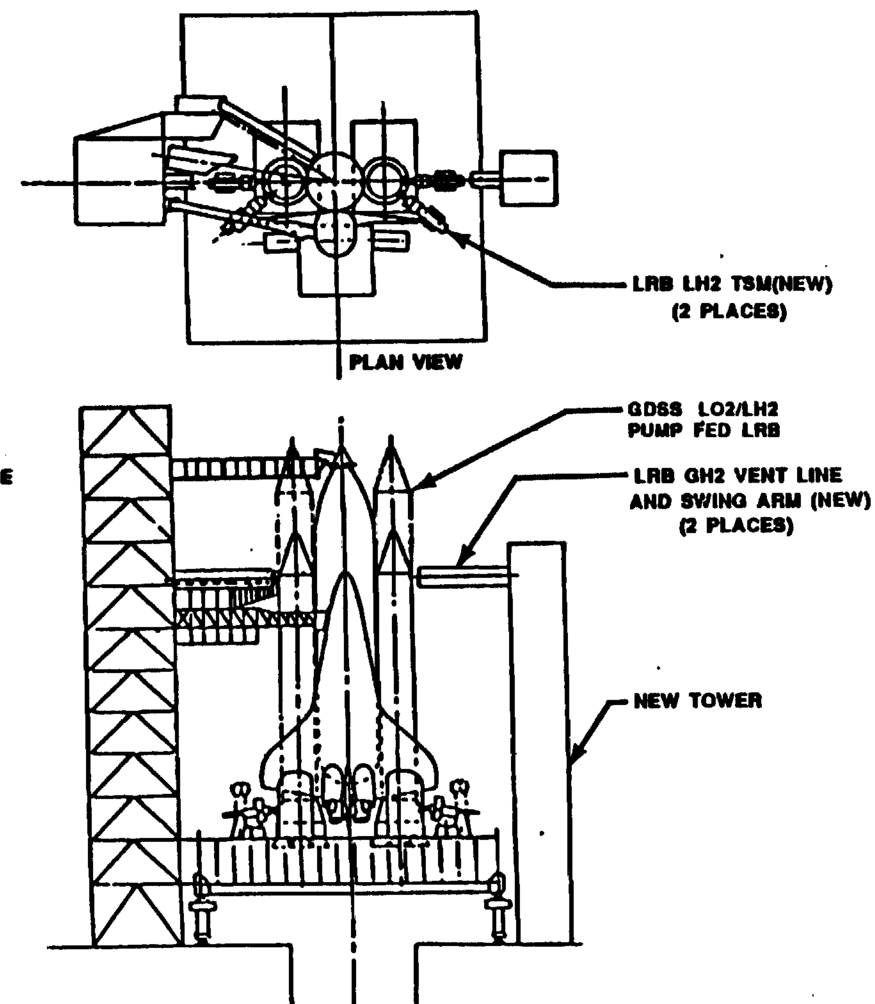
LRB UMBILICAL SYSTEMS



MMC LO2/RP-1 PUMP FED LRB UMBILICAL BASELINE
(NO UMBILICAL DELTAS FOR GDSS LO2/RP-1 PUMP FED OR MMC LO2/RP-1 PRESSURE FED LRB SYSTEMS)



GDSS LO2/LH2 PUMP FED LRB UMBILICAL DELTA

LAUNCH PAD ACCESS PLATFORMS

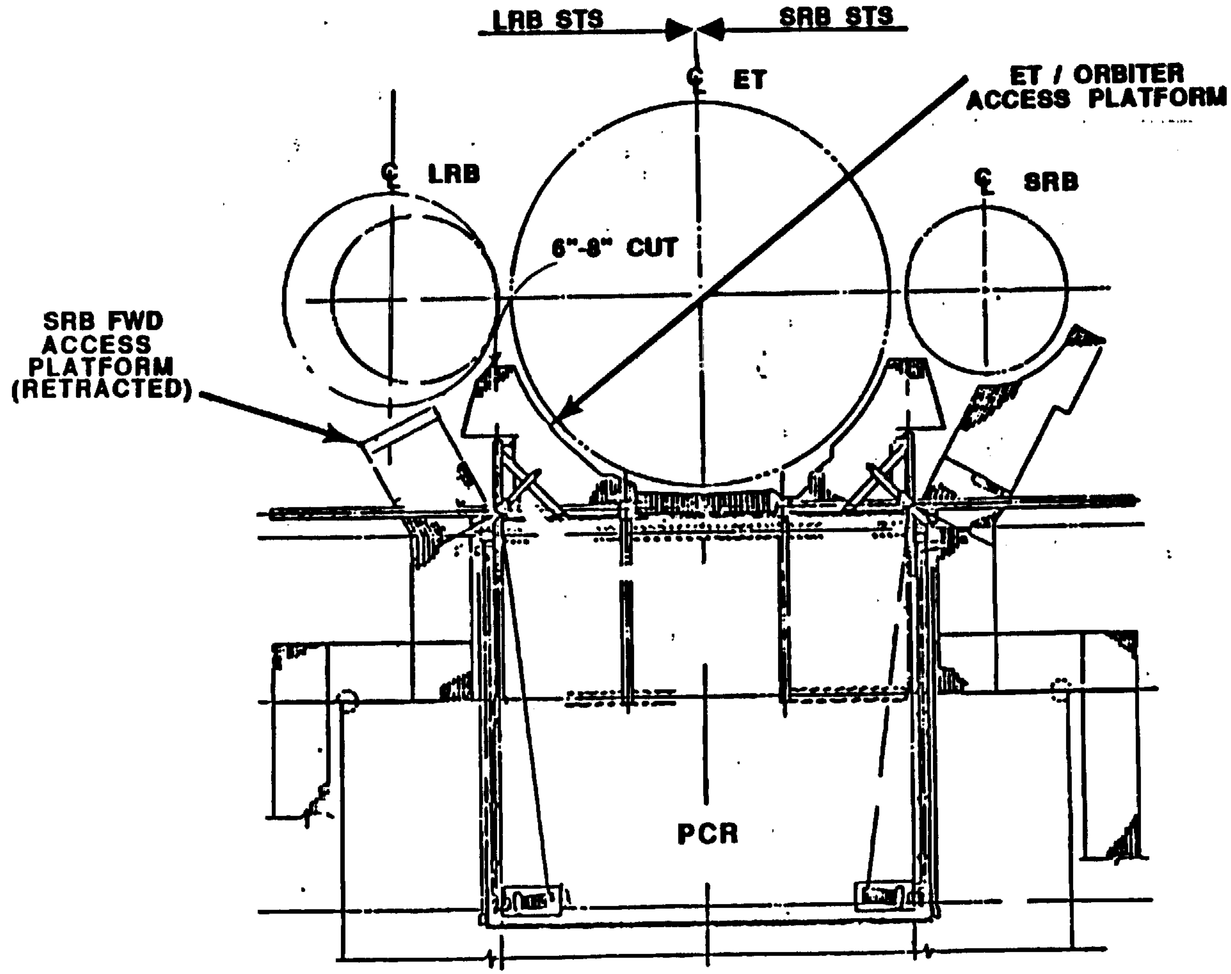
TO MAINTAIN DUAL LAUNCH CAPABILITY FOR LRB AND SRB THE EXISTING PLATFORM SYSTEM REQUIRES MODIFICATION TO ACCOMMODATE THE DIAMETERS OF BOTH BOOSTERS.

ACCESS MUST BE MAINTAINED FOR FORWARD SRB, ET/ORBITER AND TPS REQUIREMENTS. NEW ACCESS REQUIREMENTS FOR LRB WILL INCLUDE: FORWARD, INTERTANK, AND AFT.

MORE DETAILED STUDIES ARE REQUIRED FOR EACH LRB CONFIGURATION TO DETERMINE THE FEASIBILITY AND EXTENT OF THESE MODIFICATIONS.

FOR THE GDSS LOX/LH_2 AND GDSS LOX/RP1 PRESSURE-FED, FORWARD ACCESS FROM THE RSS ROOF WILL IMPACT THE LOAD LIMITATIONS OF THE RSS. THE SRB AFT INTEGRATED ELECTRONIC ASSEMBLY (IEA) PLATFORMS CAN BE STOWED FOR LRB LAUNCH CONFIGURATIONS.

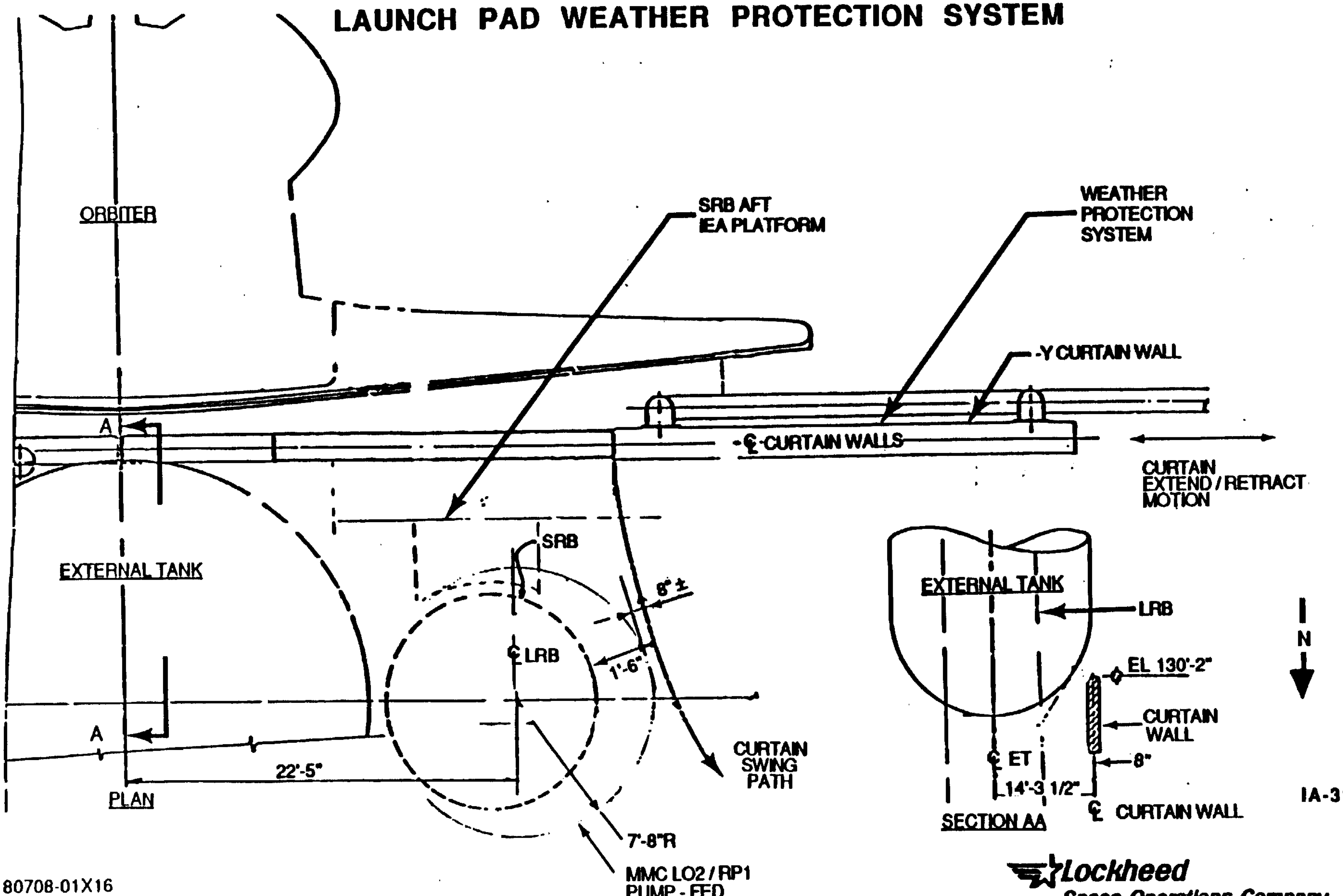
LAUNCH PAD ACCESS PLATFORMS



WEATHER PROTECTION SYSTEM

MAJOR MODIFICATIONS WILL BE REQUIRED. FOR EXAMPLE, SWING CLEARANCE FOR THE -Y CURTAIN WALL IS REDUCED TO 8" FOR MMC LOX/RP1 PUMP FEED. THE HINGE POINT FOR ROTATING THE CURTAIN WALL WOULD NEED TO BE MODIFIED TO PROVIDE ADEQUATE CLEARANCE OF 1'-6" MINIMUM. A DETAILED STUDY IS REQUIRED TO DETERMINE THE EXTENT AND FEASIBILITY OF THE REQUIRED MODIFICATIONS.

LAUNCH PAD WEATHER PROTECTION SYSTEM



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PROPELLANT FACILITIES

- PROPELLANT STORAGE
- LOX TRANSFER AND STORAGE
- LH2 TRANSFER AND STORAGE
- RP1 TRANSFER AND STORAGE

PROPELLANT STORAGE

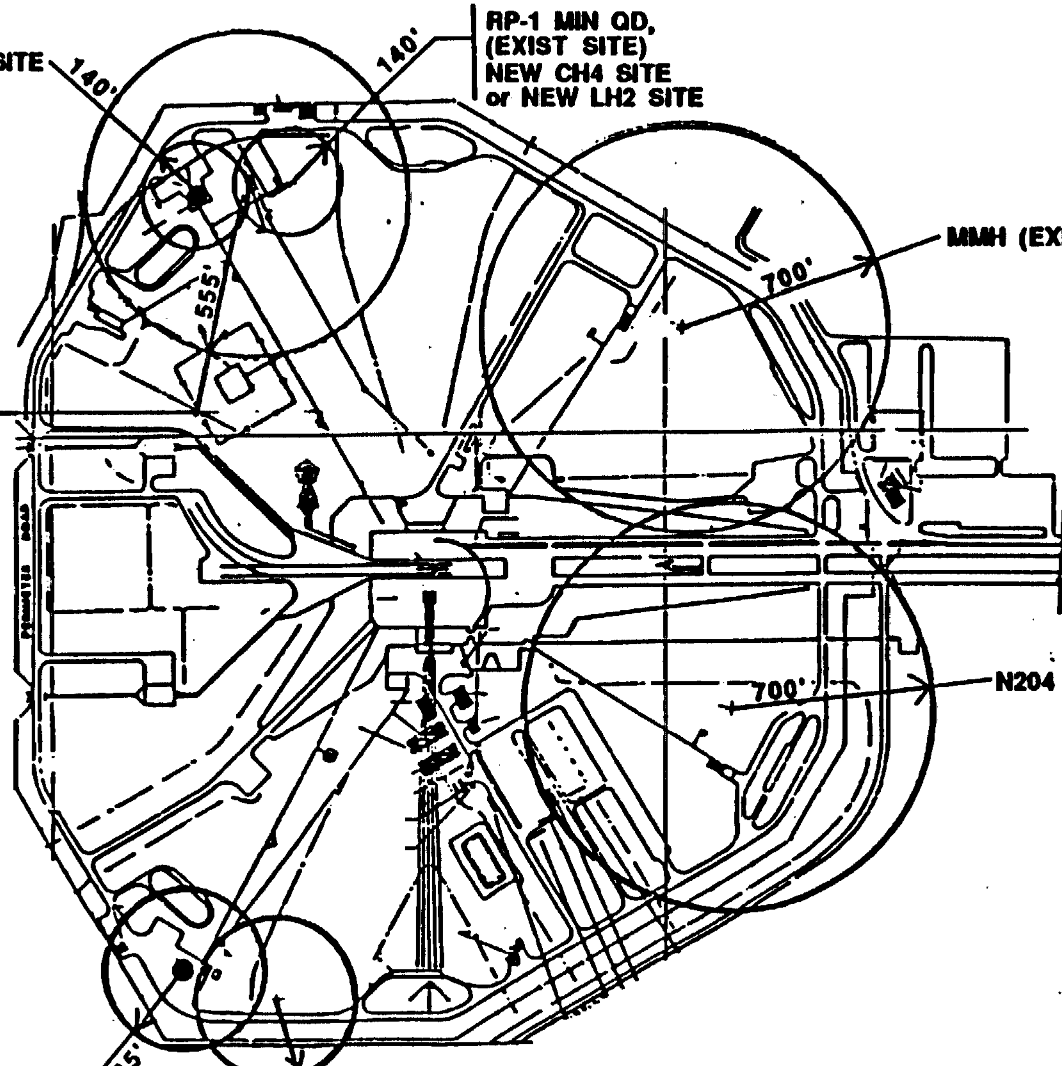
THE CRYOGENIC (LO_2 AND LH_2) PROPELLANT REQUIREMENT FOR THE 6 LRB CONFIGURATIONS HAVE BEEN REVIEWED FOR IMPACT ANALYSIS AND CONCEPTS FOR TRANSFER ARE BEING DEVELOPED.

THE RPI PROPELLANT REQUIREMENTS FOR THE 4 LRB CONFIGURATIONS HAVE BEEN REVIEWED AND THE CONCEPTS FOR TRANSFER ARE BEING DEVELOPED.

ANALYSIS AND REVIEW OF THE METHANE PROPELLANT REQUIREMENT HAS STARTED.

QUANTITY/DISTANCE REQUIREMENTS FOR LAUNCH PAD STORAGE FACILITIES HAVE BEEN DETERMINED FOR THE VARIOUS PROPELLANTS.

PROPELLANT STORAGE



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LOX TRANSFER & STORAGE

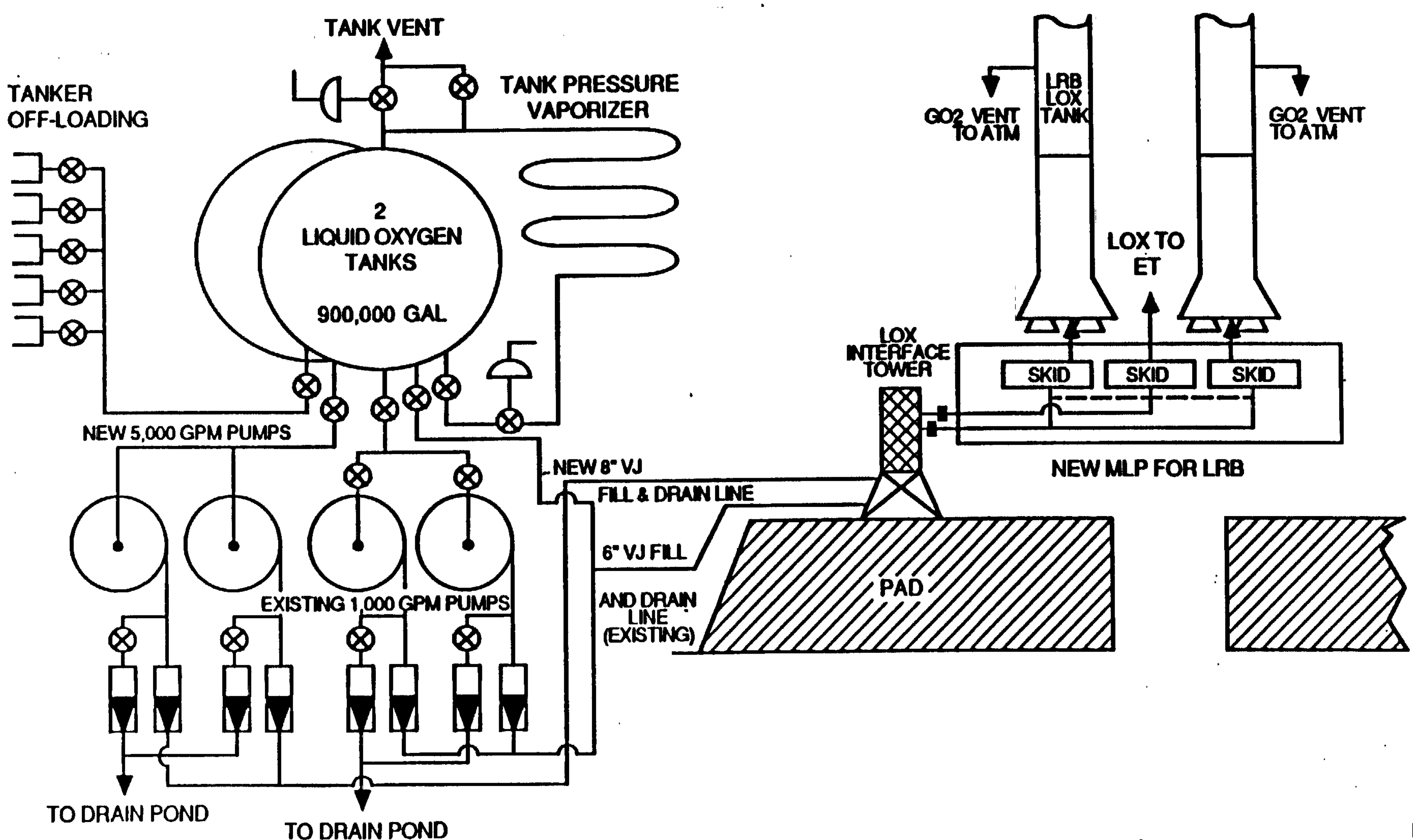
THREE CONCEPTS FOR TRANSFER ARE BEING STUDIED BASED ON FAST FILL:

- o HOLD EXISTING TIME LINE - LRB LOADED BY INDEPENDENT PUMP AND 8" CROSS-COUNTRY LINE (PREFERRED.)
- o USE EXISTING 1M PUMP AND 6" CROSS-COUNTRY LINE AND INCREASE LOADING TIME LINE.
- o HOLD EXISTING TIMELINE - LRB AND ET LOADED BY INDEPENDENT PUMP AND 10" CROSS-COUNTRY LINE, EXISTING SYSTEM USED FOR SRB/ET CONFIGURATION.

THE PREFERRED CONCEPT MAINTAINS THE TIMELINE AND PROVIDES A NEW TRANSFER SYSTEM FOR LRB USING A 8" VJ LINE AND 5M PUMPS. THIS WILL ALLOW INDEPENDENT LOADING OF LRB & ET. THE PRESENT STORAGE DOES NOT PERMIT A SCRUB/TURNAROUND WITHOUT REPLENISH OF STORAGE VESSEL. THEREFORE, A SECOND LOX TANK IS REQUIRED.

PRESENT LOX VESSEL REPLENISH CAPABILITY PERMITS 210,000 GAL/WEEK (42,000 GAL/DAY). ADDITIONAL TANKERS WOULD ALLOW ACQUISITION OF 84,000 GAL/DAY.

LIQUID OXYGEN SERVICING SYSTEM



LH2 TRANSFER AND STORAGE

LH2 TRANSFER CAN BE ACHIEVED USING THE EXISTING 10" CROSS-COUNTRY LINE WITH LRB LOADING EQUIPMENT CONNECTED UPSTREAM OF ET LOADING EQUIPMENT.

THE PRESENT STORAGE DOES NOT PERMIT LOADING OF LRB/ET AND AN ADDITIONAL STORAGE VESSEL MUST BE PROVIDED.

THE DOUBLING OF THE STORAGE DOES NOT PERMIT A SCRUB/TURNAROUND.

THE PRESENT LH2 VESSEL REPLENISH CAPABILITY PERMITS 200,000 GAL/WEEK, THEREFORE DOUBLING THE FILL STATIONS AND TANKER FLEET WILL BE REQUIRED.

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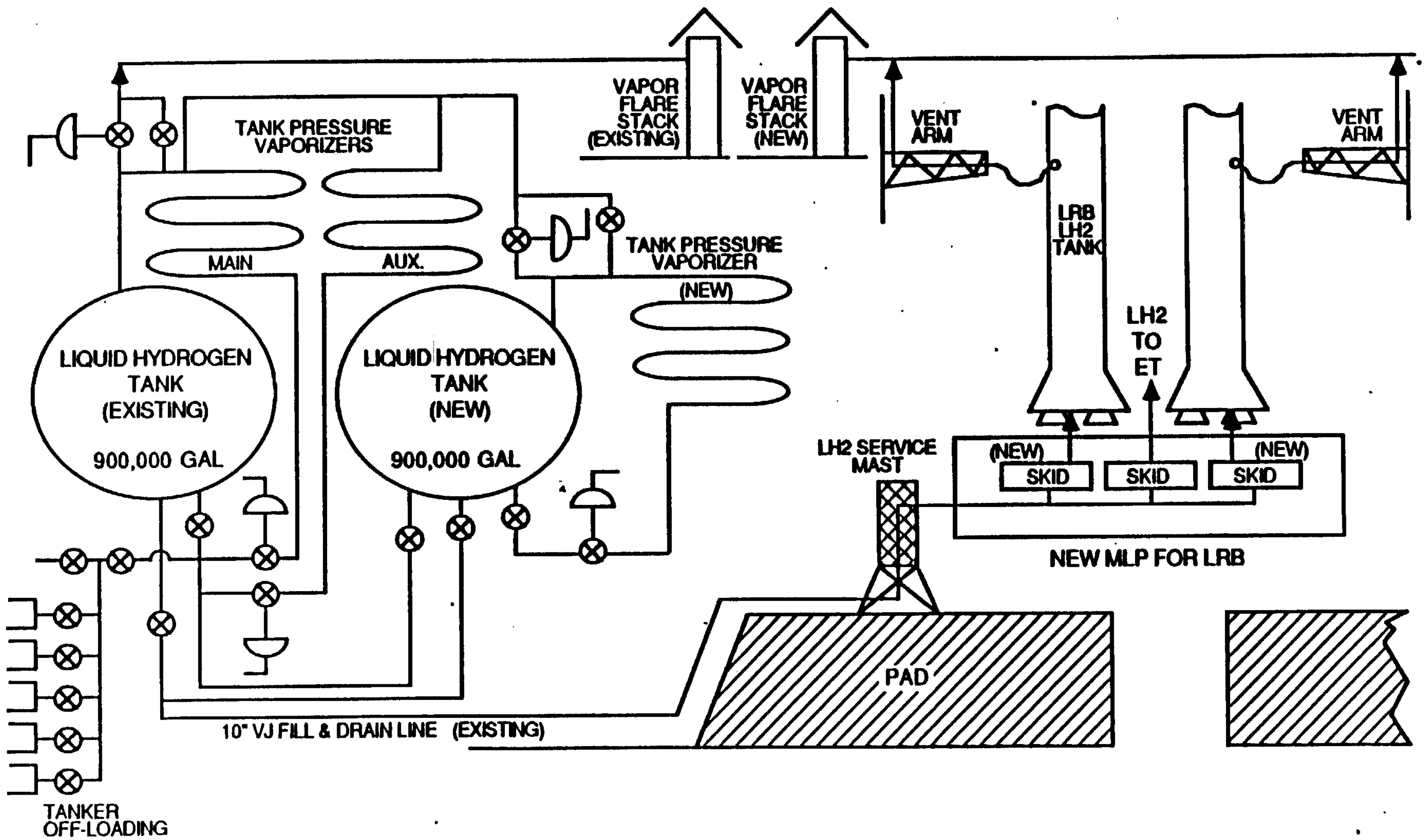
LIQUID HYDROGEN SERVICING SYSTEM



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RP1 TRANSFER AND STORAGE

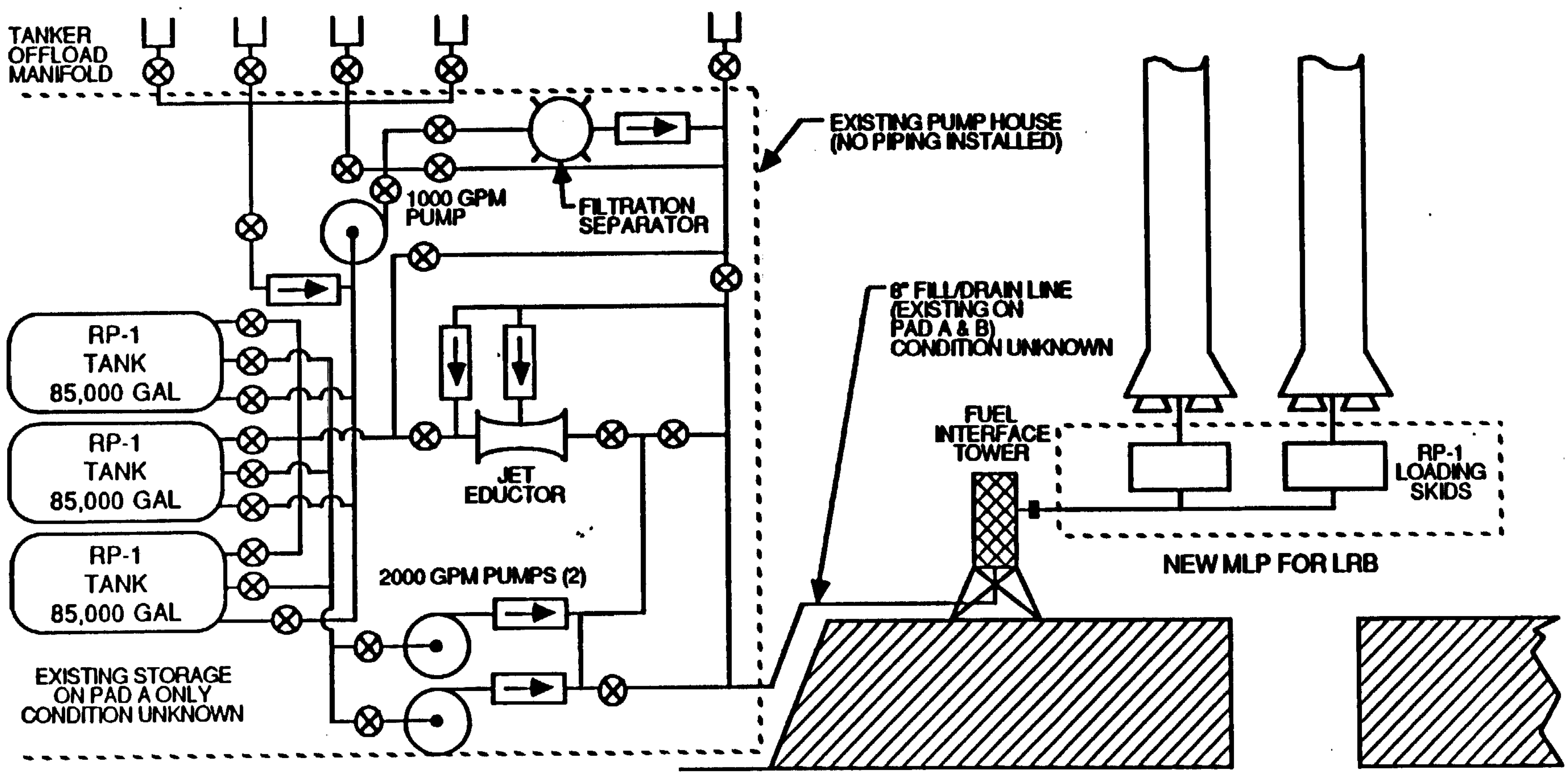
THE CONDITION OF THE STORAGE VESSELS ON PAD B IS UNKNOWN (PAD A VESSELS REMOVED) AND HAVE NOT BEEN MAINTAINED. BASED ON THE FACT OF LACK OF MAINTENANCE AND THAT EPA REGULATIONS FOR UNDERGROUND FUEL STORAGE HAVE BEEN TIGHTENED, THE STUDY IS PROCEEDING ON THE ASSUMPTION NEW VESSELS ARE REQUIRED. THE TRANSFER LINES ON BOTH PADS HAVE ALSO NOT BEEN MAINTAINED AND THE CONDITION IS UNKNOWN. A COST TRADE FOR REPLACEMENT OR REFURBISHMENT IS REQUIRED TO DETERMINE WHICH APPROACH IS COST EFFECTIVE AND WILL PROVIDE A SAFE TRANSFER SYSTEM INTO THE 21ST CENTURY.

THE APOLLO CONCEPT OF THREE 85,000 GALLON VESSELS IS SUFFICIENT FOR ALL LRB CONFIGURATIONS.

AN OPTION TO PROVIDE A CENTRAL RP1 STORAGE FACILITY BETWEEN THE PADS ON BEACH ROAD HAS BEEN CONSIDERED. THIS OPTION REQUIRES TRANSFER OF RP1 ACROSS WET-LANDS WHICH WILL REQUIRE AN ENVIRONMENTAL IMPACT STUDY.

LIQUID ROCKET BOOSTER INTEGRATION FIRST PROGRESS REVIEW

RP-1 SERVICING SYSTEM



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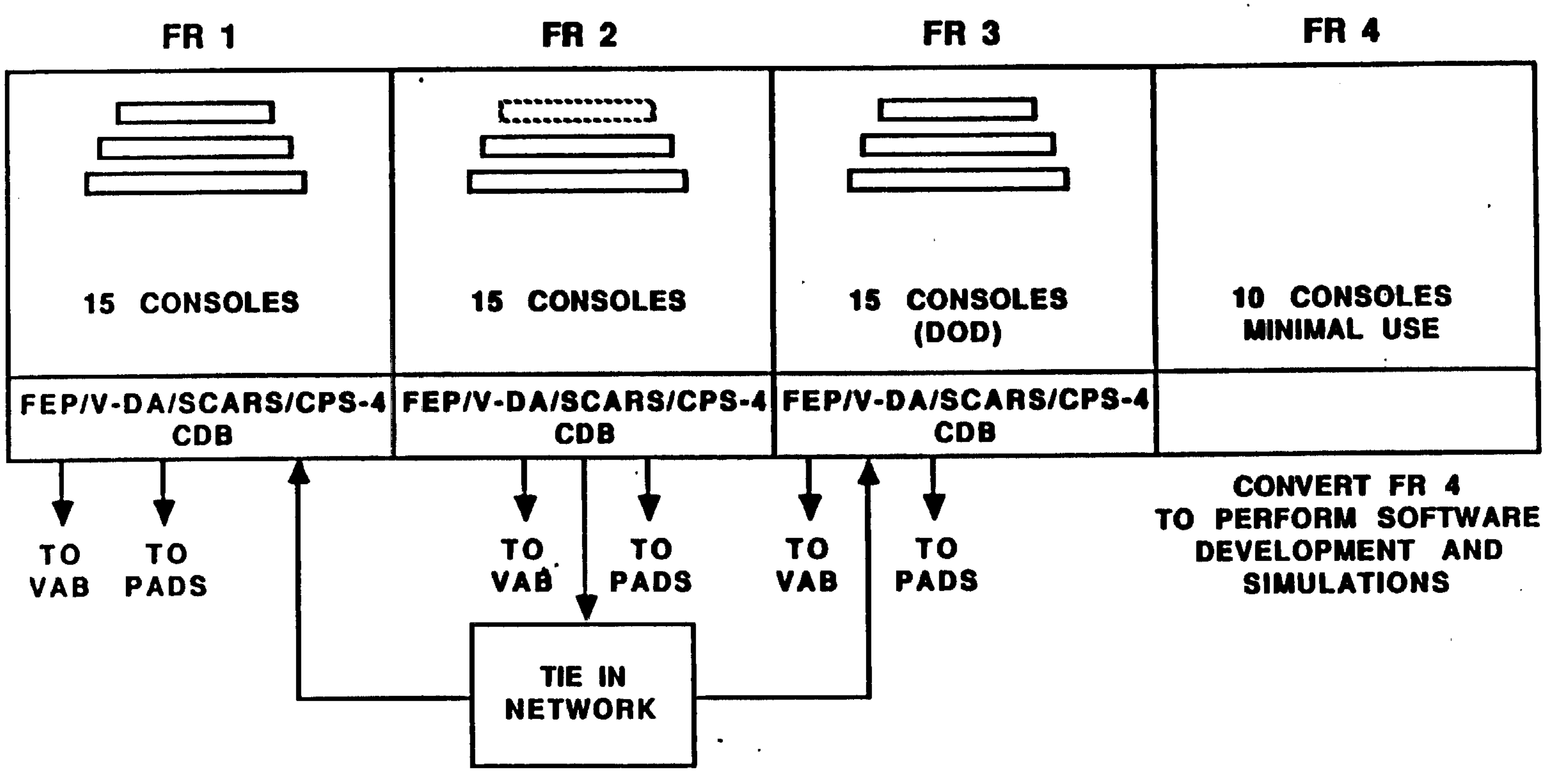
LCC

LCC FIRING ROOMS

AT THE PRESENT TIME FIRING ROOM (FR) 1, 2, & 3 HAVE A MAXIMUM CAPACITY OF 15 CONSOLES/CPU(S) EACH DUE TO SPACE AND SOFTWARE LIMITATIONS. ADDITIONAL CONSOLES/CPU(S) MAY BE REQUIRED TO SUPPORT AN INTEGRATED STS/LRB STACK WHILE MAINTAINING STS/SRB CAPABILITY. OPTIONS FOR INTEGRATING LRB REQUIREMENTS INTO THE LCC IS TO UTILIZE CONSOLES IN FR 2 TO TIE IN WITH FR 1 AND 3 OR DEVELOP SOFTWARE CAPABILITY TO SHARE EXISTING CONSOLES. EXPANSION OF THE SOFTWARE TO ACCOMMODATE LRB REQUIREMENTS WITHOUT EFFECTING THE SRB REQUIREMENTS IS REQUIRED.

LIQUID ROCKET BOOSTER INTEGRATION FIRST PROGRESS REVIEW

LCC FIRING ROOMS



TIE IN NETWORK

- CONNECT FR 2 TO FR 1 & 3 TO TEST SHUTTLE LRB STACK. TO TEST SHUTTLE SRB STACK FR 2 IS NOT REQUIRED.

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LC-39

- LC-39 POWER REQUIREMENTS
- OTHER SERVICE / UTILITY IMPACTS
- MLP PARKSITE #2

LC39 POWER REQUIREMENTS

THE ADDITIONAL LOAD REQUIREMENTS TO SUPPORT LRB WILL REQUIRE THE EXPANSION OF THE C-5 SUBSTATION. ADDITIONAL TRANSFORMERS AND SWITCHING PANELS WILL BE NEEDED.

EMERGENCY GENERATOR POWER PANELS WILL NEED TO BE EXPANDED TO SUPPORT THE ADDITIONAL EMERGENCY POWER REQUIREMENTS.

THE LCC AND LRB/ET PROCESSING FACILITY WILL REQUIRE ADDITIONAL UPS.

THE PAD LOX AND FUEL SITES, MLP PARKSITE AND LRB/ET PROCESSING FACILITY WILL REQUIRE ADDITIONAL SUBSTATIONS.

ADDITIONAL FEEDERS WILL BE REQUIRED FOR ALL NEW SITES AND EXPANDED SITES FOR BOTH FACILITY AND EMERGENCY POWER.

LIQUID ROCKET BOOSTER INTEGRATION FIRST PROGRESS REVIEW

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LC-39 POWER REQUIREMENTS

SITES	FACILITY 60HZ PWR	EMERGENCY 60HZ PWR	UPS
C-5 SUBSTATION & GENERATORS	SUBSTATION WILL NEED TO PROVIDE 8-13.8KV 32000A FEEDERS	C-5 EMERGENCY GENERATORS SYSTEM WILL NEED TO PROVIDE 4-480V @ 400 AMP FEEDERS	N/A
LRB & ET PROCESSING FACILITY	2-2000AMP SUBSTATION (DOUBLE ENDED) 2-13.8 KV FEEDERS	1-480V @ 400 AMP FEEDER	1- 600KV
MLP PARK SITE (#2)	2-13.8KV FEEDERS	1-480V @ 400 AMP FEEDER	N/A
PAD LOX	1- 13.8KV FEEDER 1- 2000 AMP SUBSTATION	1-400 AMP EMERGENCY	N/A
PAD FUEL	1-13.8KV FEEDER 1-2000 AMP SUBSTATION	1-400 AMP EMERGENCY	N/A
LCC	TBD	TBD	3-600KV
NEW MLP	2-1600 AMP SUBSTATION (DOUBLE ENDED)	1-480V @ 400 AMP FEEDER	N/A
MLP 1, 2 AND/OR 3	N/A	N/A	N/A
VAB HI-BAY 4 (ALL NEW)	2-13.8KV FEEDERS	N/A	N/A
VAB HI-BAY 3	N/A	N/A	N/A

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OTHER SERVICE / UTILITY IMPACTS

- TELEPHONE SYSTEM
- OIS / COMM

MLP PARKSITE #2

DUE TO THE REQUIREMENT FOR CONSTRUCTION AND ACTIVATION OF A NEW MLP, REACTIVATION OF MLP PARKSITE #2 IS MANDATORY. INITIALLY, THE PARKSITE WILL BE DEDICATED AS A CONSTRUCTION SITE FOR THE NEW MLP, REQUIRING INSTALLATION OF MOUNT MECHANISMS. DURING THE ACTIVATION PHASE OF THE NEW MLP, PARKSITE REQUIREMENTS ARE MORE SOPHISTICATED. THIS INCLUDES INSTALLATION OF ACCESS TOWERS, POWER, COMMUNICATIONS, AND VARIOUS MECHANICAL UTILITIES.

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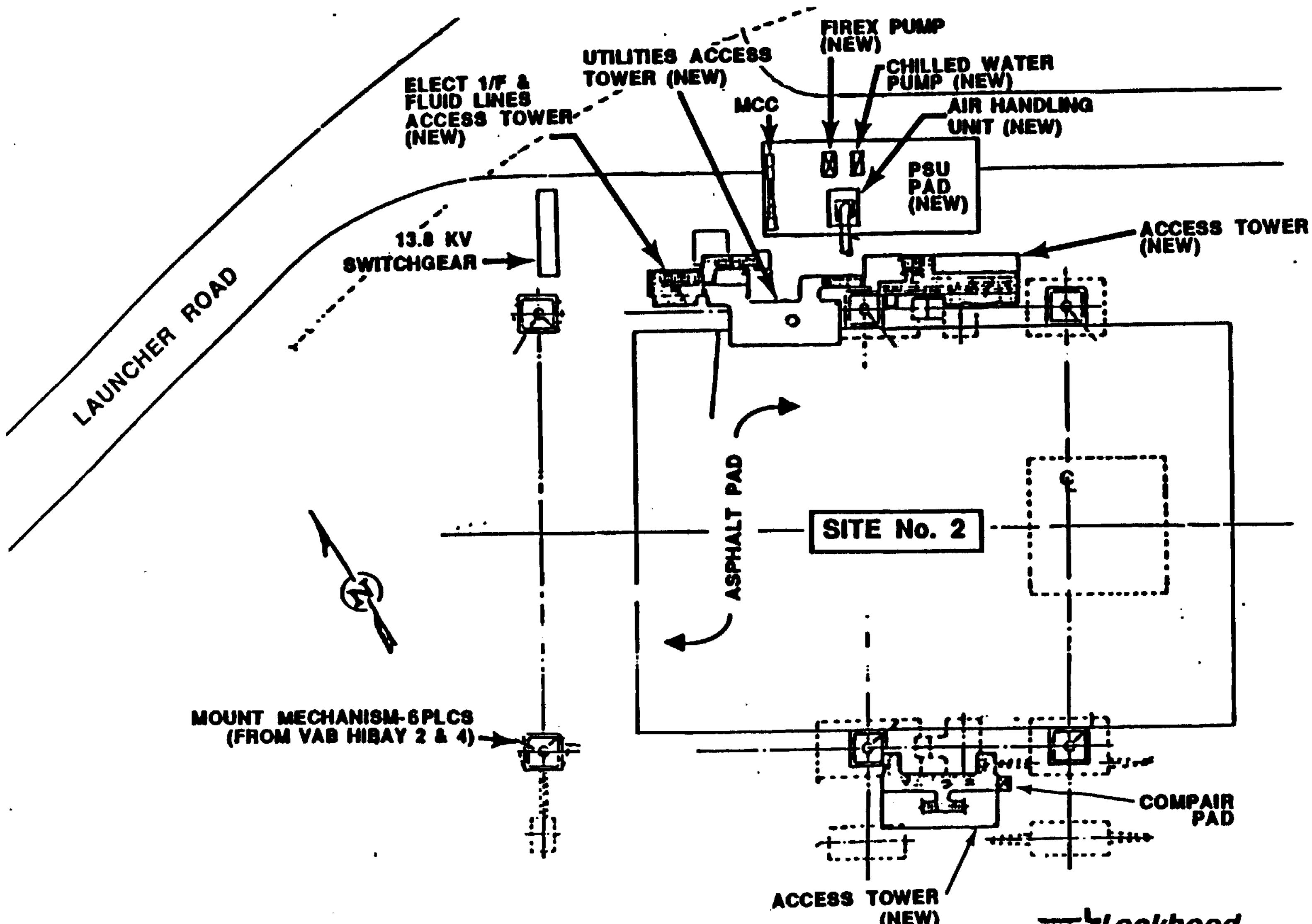
MLP PARKSITE #2



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LETF

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LAUNCH EQUIPMENT TESTING FACILITY (LETF)

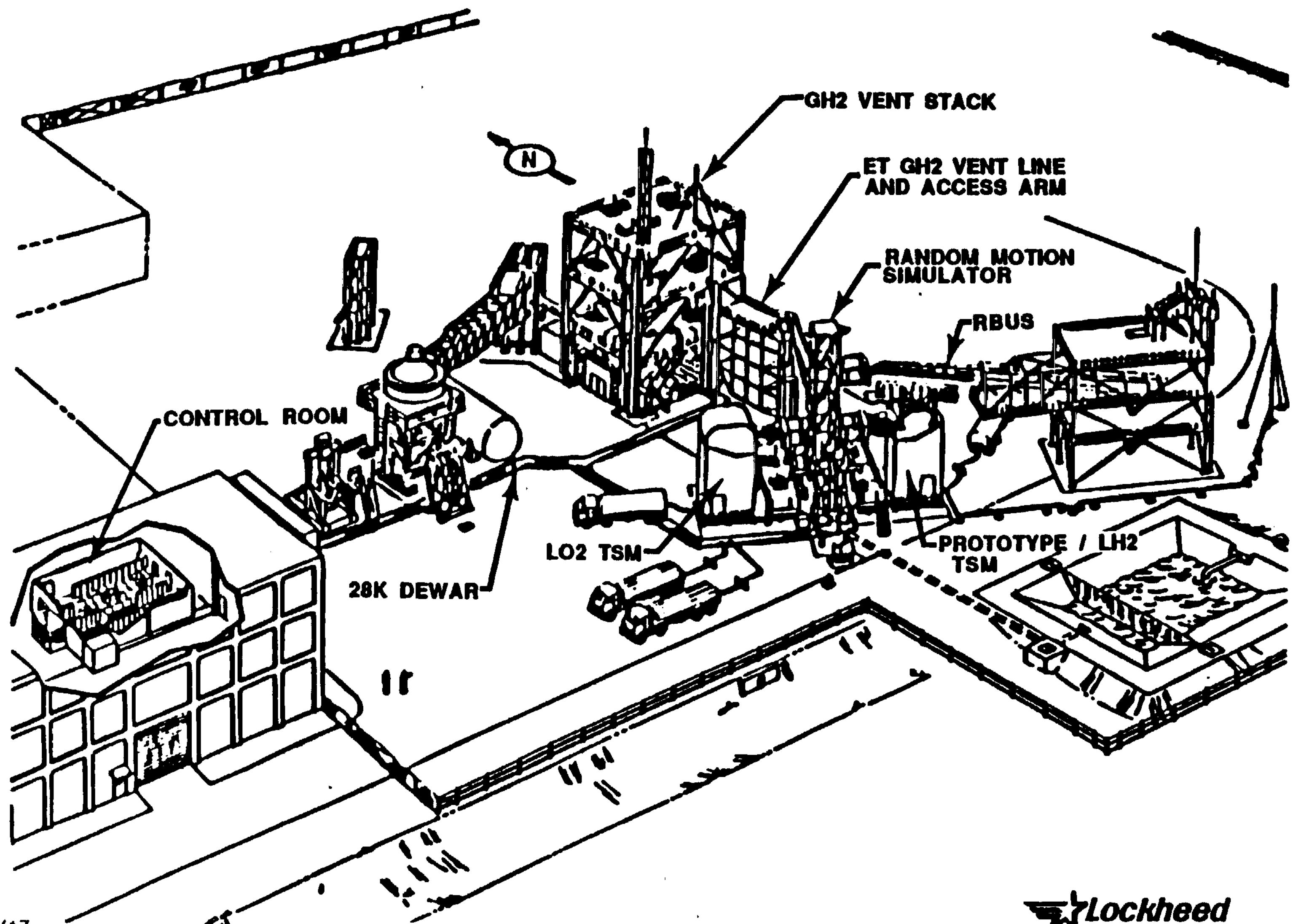
THE LAUNCH EQUIPMENT TEST FACILITY (LETF) PROVIDES THE CAPABILITY FOR THE OPERATIONAL QUALIFICATION AND CERTIFICATION OF LAUNCH SUPPORT EQUIPMENT (LSE). THE FACILITY TESTS LSE BY SIMULATION OF VEHICLE MOTION (BEFORE LAUNCH, AT LIFT-OFF, DURING FLUID FLOW) AND VERIFIES THE SYSTEM FOR OPERATIONAL PERFORMANCE, EMERGENCIES, HOLDS AND OTHER CONTINGENCIES.

THE LRB LSE WILL REQUIRE SUCH QUALIFICATION AND CERTIFICATION. THE LSE IDENTIFIED FOR TESTING INCLUDE THE TWO LOX FILL & DRAIN (F/D) UMBILICALS, TWO FUEL F/D UMBILICALS, TWO FUEL VENT UMBILICALS, TWO POWER/INSTRUMENTATION UMBILICALS AND THE EIGHT HOLDDOWN DEVICES FOR EACH MLP/PAD.

THE REQUIRED REDESIGN OF THE ET H_2 VENT WILL ALSO REQUIRE RE-QUALIFICATION AND CERTIFICATION. THE GOX VENT ARMS AND ALL TSMs WOULD REQUIRE RE-TEST IF MODIFICATIONS OR CHANGES ARE MADE.

THE IMPACT TO THE FACILITY INCLUDES ADDITION OF TOWERS/INTERFACE SIMULATORS FOR THE LRB LSE TESTS. MODIFICATIONS TO THE EXISTING ET/SHUTTLE SIMULATORS MAY BE REQUIRED.

LAUNCH EQUIPMENT TEST FACILITY (LETF)



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SAFETY / ENVIRONMENTAL

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SAFETY/ENVIRONMENTAL IMPACTS

SAFETY AND ENVIRONMENTAL IMPACTS ARE BEING ADDRESSED FOR EACH LRB CONFIGURATION AND PROCESSING CONCEPT. THESE IMPACTS ARE BASED ON RESEARCH OF APPLICABLE SAFETY AND ENVIRONMENTAL RULES, REGULATIONS, STANDARDS AND CODES; DATA PROVIDED BY THE MARSHALL PHASE "A" STUDY CONTRACTORS; AND STUDY GROUNDRULES (PUMP FED LOX/RP-1 PROPELLANTS).

THE SAFETY IMPACTS ARE ADDRESSED FROM A STANDPOINT OF THOSE THAT WOULD BE GENERIC TO ANY PROGRAM OF THIS NATURE AND THOSE THAT ARE FELT TO BE UNIQUE TO THE LRB. IMPACTS FROM AN ENGINEERING, OPERATIONAL AND INDUSTRIAL SAFETY POINT OF VIEW ARE BEING ADDRESSED.

THE ENVIRONMENTAL IMPACTS ADDRESSED ARE THOSE WHICH WOULD BE GENERATED BY ANY MAJOR PROGRAM OF THIS TYPE.

SAFETY/ ENVIRONMENTAL IMPACTS

SIGNIFICANT ITEMS WHICH ARE BEING ADDRESSED IN THE STUDY ARE

(1) MAJOR GROUND SAFETY ENHANCEMENTS

- NO LIVE PROPELLANTS IN VAB
- REDUCED STACKING OPERATIONS
- ELIMINATES NEED FOR RPSF

(2) MAJOR ENVIRONMENTAL ENHANCEMENTS

- CLEANER COMBUSTION BY-PRODUCTS / DRASTIC REDUCTION IN ACID CLOUD PROBLEMS (INCREASED LIFE EXPECTANCY OF GSE AND REDUCTION IN CORROSION CONTROL)

(3) FLIGHT SAFETY/ABORT ENHANCEMENTS

- ABILITY TO PERFORM HEALTH VERIFICATION OF BOOSTER ENGINES PRIOR TO RELEASE
- ADDED CAPABILITY FOR ABORT MODES AFTER LIFTOFF

(4) QUANTITY DISTANCE REQUIREMENTS

- ADDITIONAL PROPELLENT STORAGE REQUIREMENTS WITHIN PAD COMPOUND
- CENTRALIZED STORAGE FACILITY FOR RP-1 BETWEEN THE PADS

(5) LRB TOW ROUTE

- NEW TOW ROUTE VS USING EXISTING TOW WAYS

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ISSUES

MLP - IMPACTS TO MLP STRUCTURAL INTEGRITY AND INFRINGEMENT ON SSME EXHAUST HOLE CAUSED BY MMC PRESSURE-FED (CLEARANCE OF GIRDER G-20)

- DRIFT DATA FOR HOLDDOWN CONCEPTS (CROSS GIRDER PLACEMENT FOR GDSS LRB HOLDDOWN)

PAD - WEIGHT & STRUCTURAL LIMITATION OF FSS FOR CANTILEVER OF GOX VENT AND ET H2 VENT REDESIGNS AND NEW LRB VENT UMBILICALS

- DRIFT DATA TO INCLUDE WORST CASE LRB ENGINE OUT FOR DESIGNING AND PLACING THE ET H2 VENT (PYRO BOLT LOADS ARE ALREADY MARGINAL)
- FLAME TRENCH DEFLECTORS AND SIDE DEFLECTORS CONCEPT WITHOUT MOD TO THE TRENCH
- NEW TOWERS FOR LRB H2 OR CH4 VENTS
- WEIGHT LIMITATIONS OF RSS FOR ACCESS TO GDSS LOX/LH2 AND LOX/RP1 PRESSURE FORWARD AREA

VAB - ACCESS TO VAB HB 4 WITH CRAWLERWAY

LCC - SPACE LIMITATIONS OF EXISTING FIRING ROOM
EXISTING SOFTWARE LIMITATIONS TO SUPPORT LRB

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ISSUES (CONT)

SAFETY:
- PROPELLANT QUANTITY / DISTANCE REQUIREMENTS
- HANDLING AND STORAGE OF CH4 AS A NEW PROPELLANT AT KSC
- HAZARD ANALYSIS

QUALITY:
- CERTIFICATION OF PRESSURE VESSELS AND SYSTEMS

RELIABILITY:
- FAILURE MODE AND EFFECTS ANALYSIS (SYSTEM ASSURANCE ANALYSIS)
- TEST PROGRAM FOR ALL REDESIGNED AND NEW UMBILICAL MECHANISMS USING VEHICLE EXCURSION AND LAUNCH DATA

MAINTAINABILITY:
- DURABILITY OF LSE / GSE

ENVIRONMENTAL:
- SITING OF LRB / ET FACILITY AND TOWAWAY ACCESS.
- SITING OF PROPELLANT STORAGE

FACILITY ACTIVATION SCHEDULE

CONCURRENT WITH DEVELOPMENT OF THE LRB PROCESSING SCENARIOS, AND DEFINITION OF STATION SET IMPACTS, IS THE EVOLUTION OF A FACILITY ACTIVATION CONCEPTUAL PLAN. THIS VERSION IS BASED UPON A FY 1991 START, A 1ST FLOW OF 8 MONTHS, WITH INITIAL LRB LAUNCH ON 1 JANUARY 1996. A 5 YEAR TRANSITION FOR 2ND AND 3RD LINE FACILITIES SUPPORTS A PROPOSED RAMP RATE OF 3/6/9/12/14 MISSIONS.

THE CURRENT CRITICAL PATH TO 1ST LRB LAUNCH IS THE DESIGN, ADVANCED PROCUREMENT, CONSTRUCTION, ACTIVATION AND OPERATIONAL CERTIFICATION OF A NEW MLP AND THE RE-ACTIVATION OF MLP PARKSITE #2.

THE PRIMARY SCHEDULE CONCERN WITH THIS PLAN, IS THE POTENTIAL MISSION RATE IMPACT TO SRB FLIGHTS, DURING CONSTRUCTION, ACTIVATION AND OPERATIONAL CERTIFICATION OF THE FIRST LAUNCH PAD.

LIQUID ROCKET BOOSTER INTEGRATION FIRST PROGRESS REVIEW

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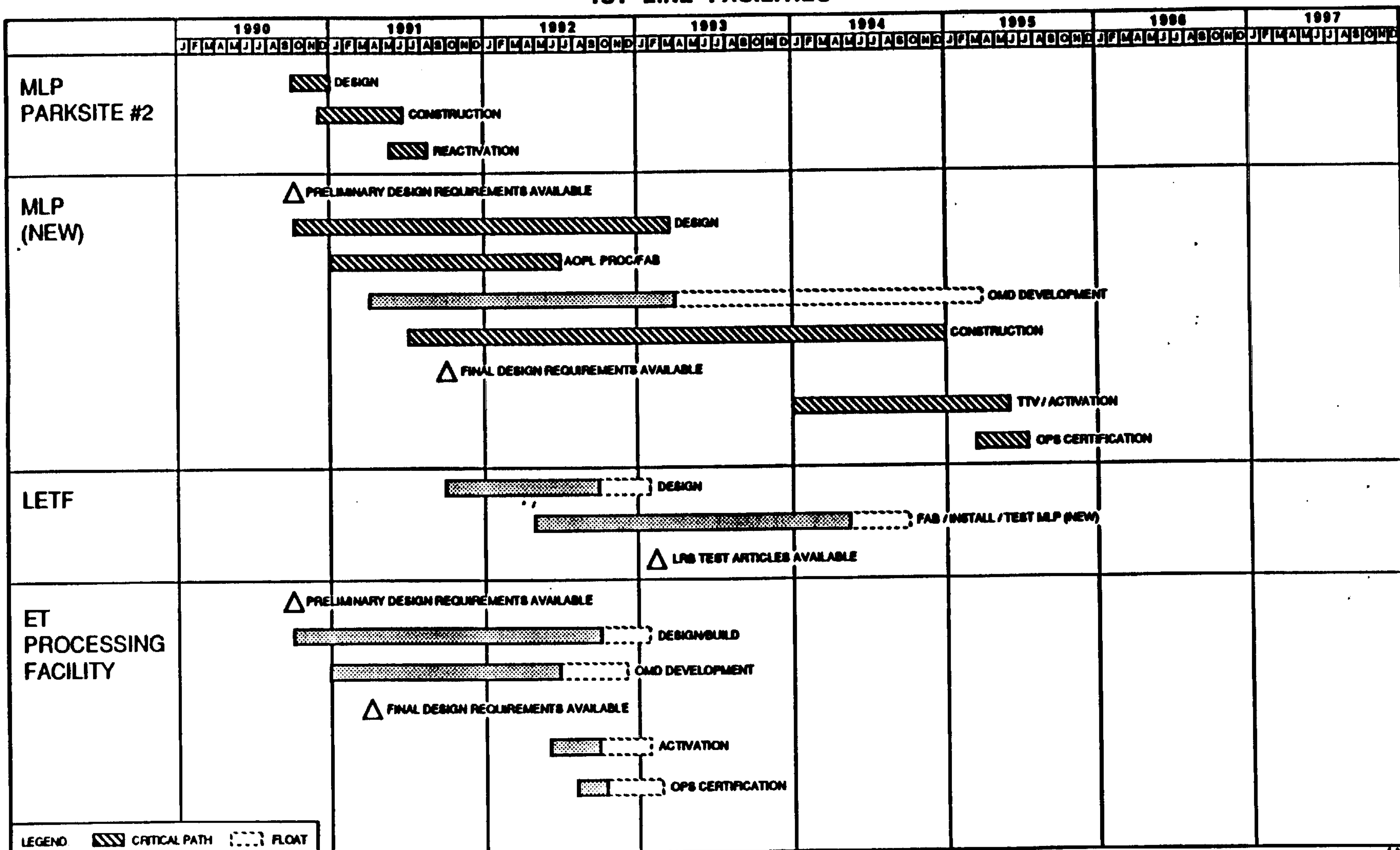
KSC FACILITY ACTIVATION CONCEPTUAL PLAN

1ST LINE FACILITIES



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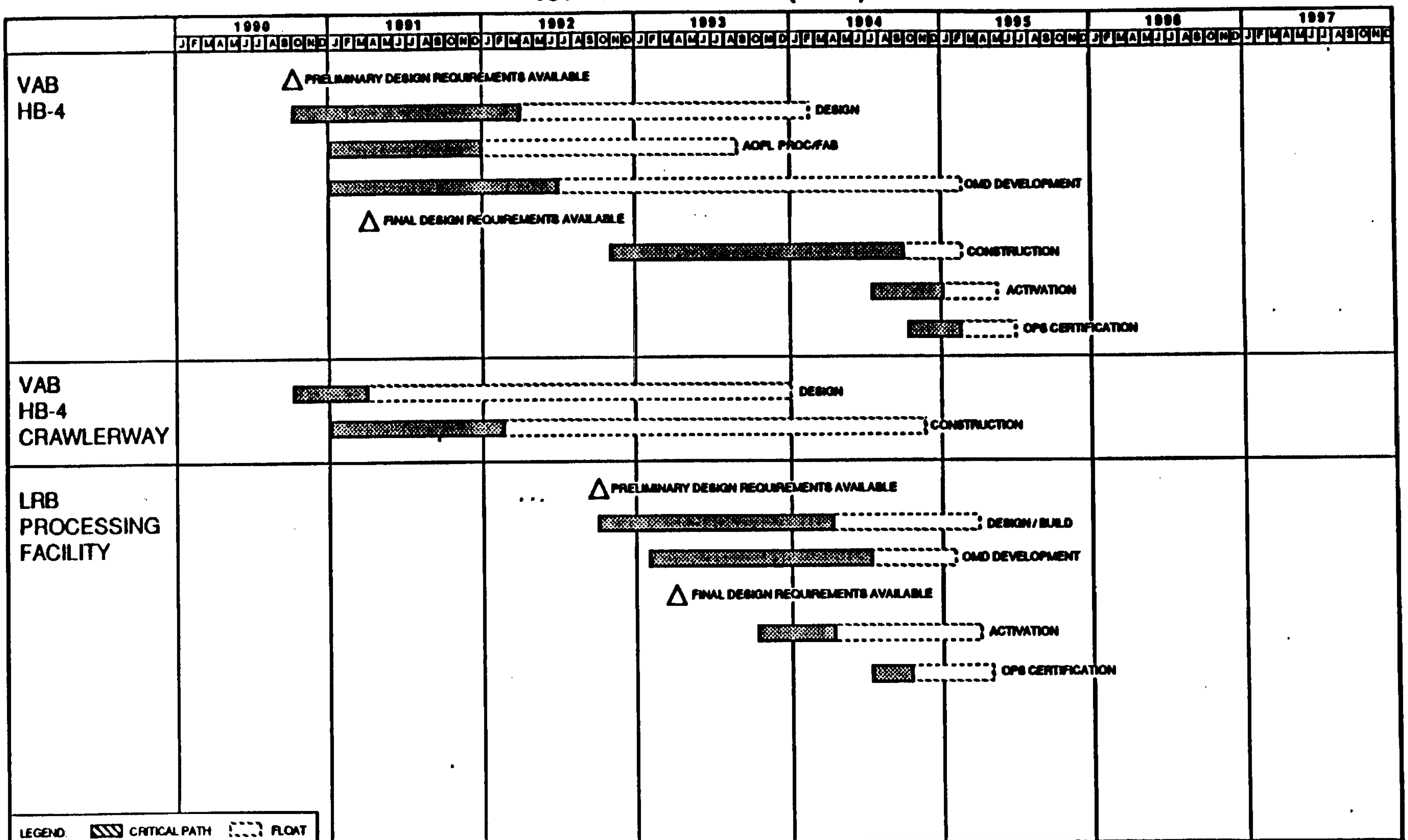
KSC FACILITY ACTIVATION CONCEPTUAL PLAN

1ST LINE FACILITIES (CONT)



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KSC FACILITY ACTIVATION CONCEPTUAL PLAN

1ST LINE FACILITIES (CONT)

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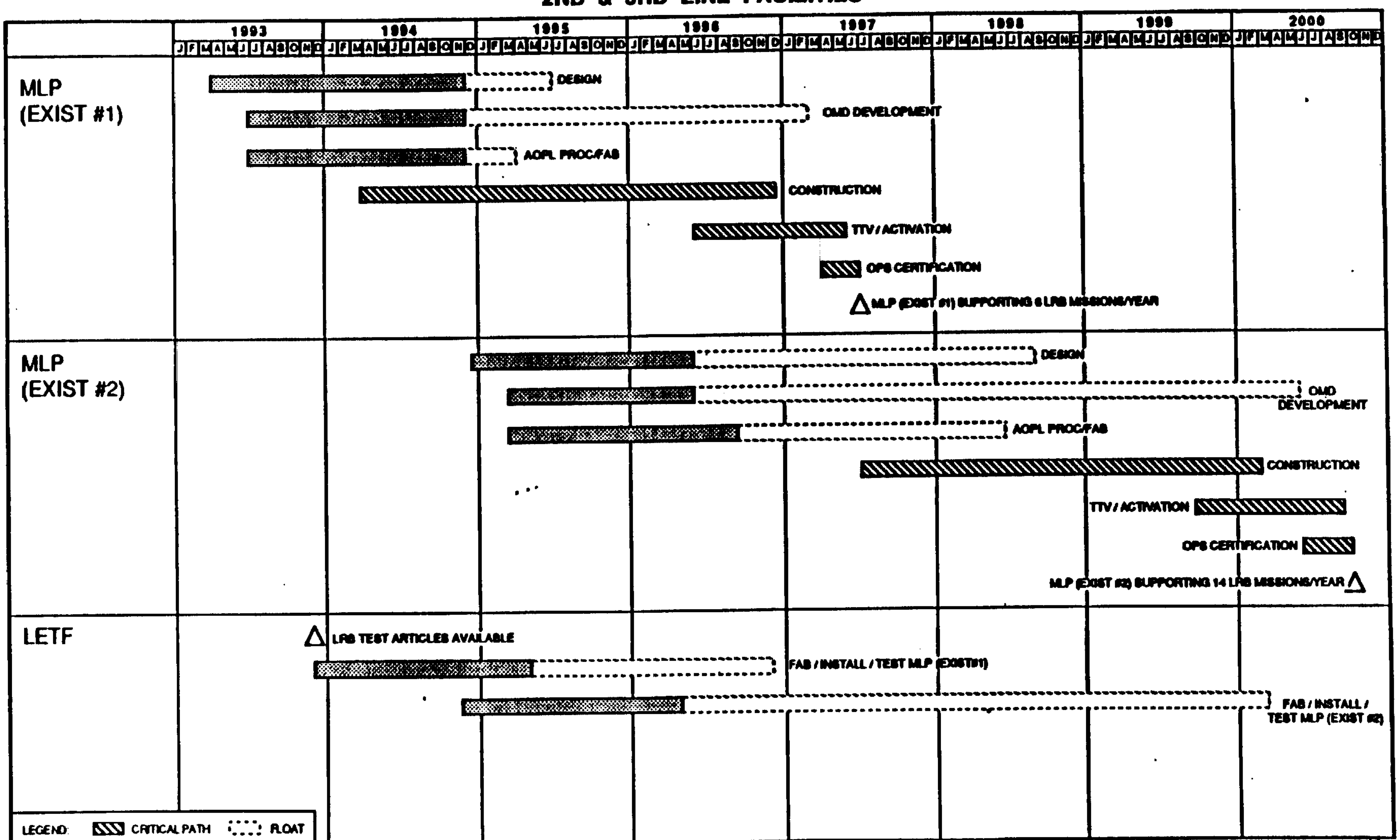
KSC FACILITY ACTIVATION CONCEPTUAL PLAN

2ND & 3RD LINE FACILITIES



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KSC ADVANCED PROJECTS & TECHNOLOGY OFFICE

LIQUID ROCKET BOOSTER INTEGRATION FIRST PROGRESS REVIEW

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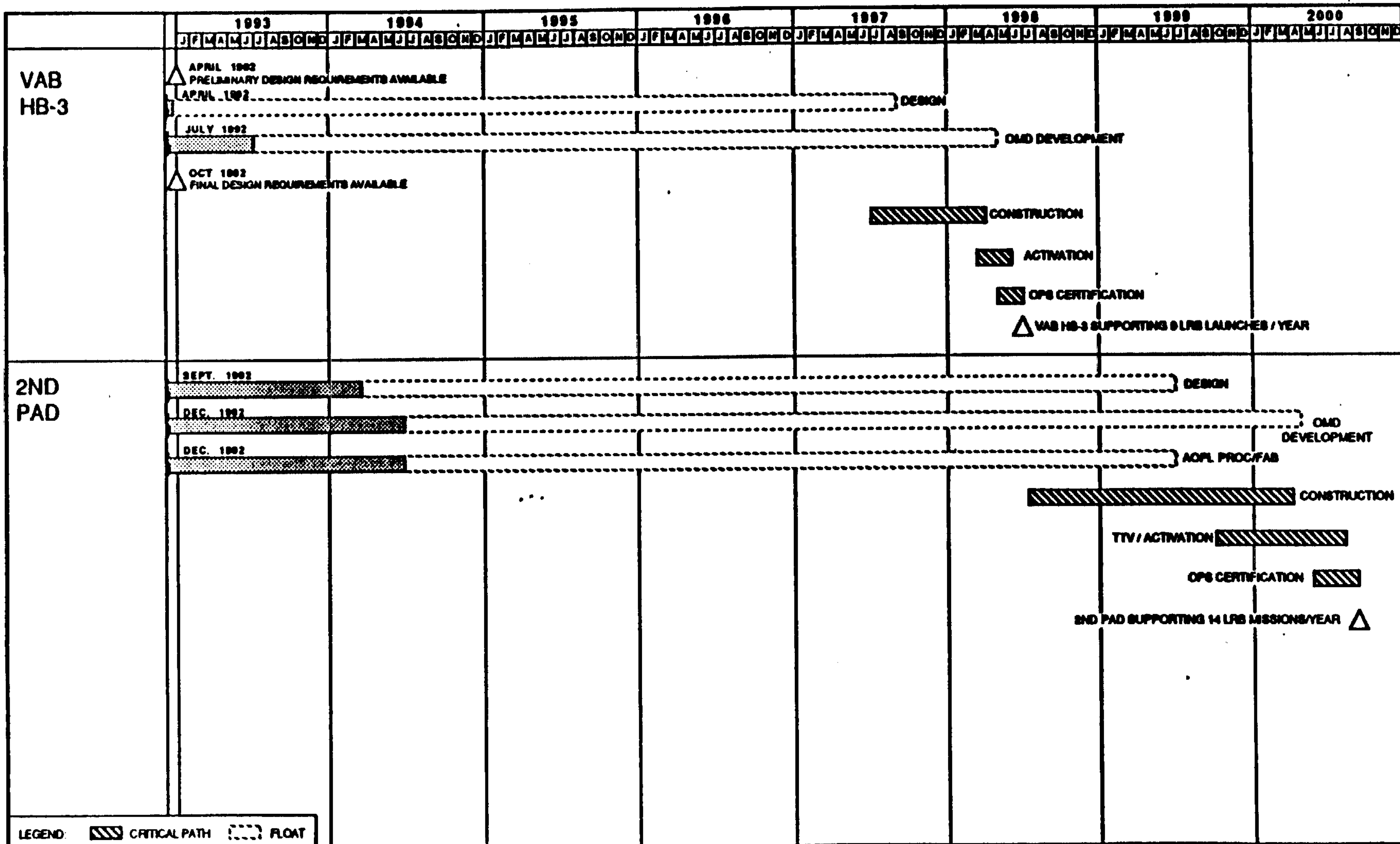
KSC FACILITY ACTIVATION CONCEPTUAL PLAN

2ND & 3RD LINE FACILITIES (CONT)



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NEAR TERM PLANS

- COMPLETE LRB/ET PROCESSING FACILITY REQUIREMENT CONCEPT
- COMPLETE LRB/ET PROCESSING FACILITY SITING TRADE STUDY
- REFINE VAB HB-4 REQUIREMENTS AND DESIGN CONCEPTS INCLUDING CRAWLERWAY IMPACTS
- CONCEPT MULTI BOOSTER PLATFORMS FOR VAB HB-3 INCLUDING EXIT INFRINGEMENTS
- REFINE MLP HOLDDOWN CONCEPTS
- DEVELOP PAD FLAME DEFLECTOR CONCEPTS
- COMPLETE PROPELLANT STORAGE, TRANSFER & ACQUISITION STUDY
- ADDRESS GROUND SOFTWARE IMPACTS

LIQUID ROCKET BOOSTER INTEGRATION FIRST PROGRESS REVIEW

JULY 1988

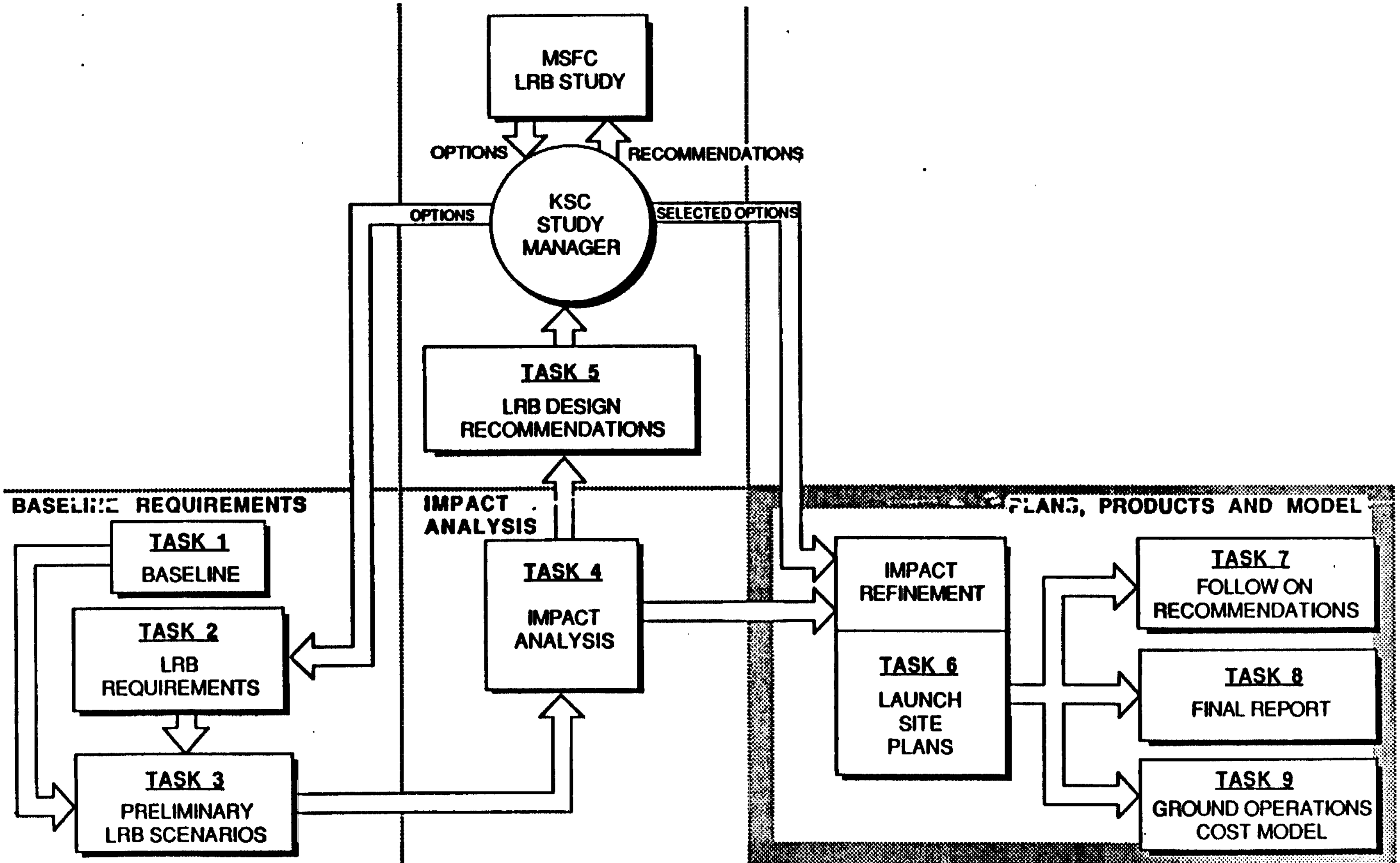
AGENDA

I. INTRODUCTION	GORDON ARTLEY
II. STUDY PROGRESS	
A) LRB PROJECT INTEGRATION	PAT SCOTT
B) BASELINE REQUIREMENTS	KEITH HUMPHRYES
C) IMPACT ANALYSIS	GREG DEBLASIO
D) PLANS, PRODUCTS AND MODEL	JERRY LEFEBVRE
III. SUMMARY	GORDON ARTLEY

PM-O

PLANS, PRODUCTS AND MODEL

JULY 1988



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PLANS, PRODUCTS AND MODELS

TASK 6 - LAUNCH SITE PLANS

TASK 7 - FOLLOW-ON RECOMMENDATIONS

TASK 8 - FINAL REPORT

TASK 9 - GROUND OPERATIONS COST MODEL

LAUNCH SITE PLANS, FOLLOW-ON RECOMMENDATIONS AND FINAL REPORT

LAUNCH SITE PLANS AND DOCUMENTS, FOLLOW-ON RECOMMENDATIONS AND FINAL REPORT (TASK 6, 7, 8 RESPECTIVELY) DERIVE THEIR SOURCE DATA FROM THE OTHER STUDY TASKS. THE FINAL ASSIMILATION OF THEIR DATA INTO FORMAL DOCUMENTS IS NOT SCHEDULED UNTIL THE LATTER PART OF THE YEAR. ROUTINE ASSESSMENT OF THE STUDY TASKS INDICATE DATA GENERATION IS ON OR AHEAD OF SCHEDULE. FOR INSTANCE A DRAFT LRB SAFETY IMPACT REPORT HAS BEEN COMPLETED.

LIQUID ROCKET BOOSTER INTEGRATION FIRST PROGRESS REVIEW

• TASK 6	LAUNCH SITE PLANS	ON SCHEDULE, NO SIGNIFICANT ISSUES
• TASK 7	FOLLOW-ON RECOMMENDATIONS	ON SCHEDULE, NO SIGNIFICANT ISSUES
• TASK 8	FINAL REPORT	ON SCHEDULE, NO SIGNIFICANT ISSUES

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GROUND OPERATIONS COST MODEL

- DEVELOPED BY NASA
- PARAMETRICALLY GENERATES STS / EQUIVALENT GROUND PROCESSING COSTS
- LSOC TASK 9
  - EXPAND AND ENHANCE THE UTILITY AND RELEVANCY OF THE GOCM TO THE STS / KSC PROGRAMS THROUGH THE INCORPORATION OF LESSONS LEARNED FROM THE LRB INTEGRATION STUDY
- TASK 9 STUDY PRODUCTS
  - USER'S MANUAL
  - RECOMMENDATIONS
  - INSTRUCTIONS
  - SOFTWARE

GOCM IS A PARAMETRIC MODEL

CURRENTLY, MAJOR EMPHASIS IS BEING PLACED ON COLLECTION OF EXISTING COST DATA FOR STS RESOURCES. GOCM COST ESTIMATING RELATIONSHIPS (CERS) WILL BE EVALUATED AND UPDATED WITH RESPECT TO LRB CONFIGURATIONS/SUPPORT SCENARIOS. ADDITIONAL LRB CERS SHALL BE INCORPORATED INTO GOCM AS A MODULE FOR SIGNIFICANT AND/OR SENSITIVE COST ELEMENTS NEEDING EITHER MODIFICATION OR INCORPORATION. GOCM WILL BE USED IN THE LRB COSTING AND WILL BE EVALUATED FOR ITS RELEVANCY AND UTILITY.

THE MIX OF COST GENERATION TECHNIQUES EMPLOYED ON A PROGRAM VARIES WITH PROGRAM MATURITY. INITIALLY DURING PHASE "A" (CONCEPTUAL EVALUATION/STUDY) AN ALL UP PARAMETRIC TECHNIQUE IS EMPLOYED WHICH PROVIDES ONLY MODERATE CONFIDENCE IN ACCURACY. THIS IS THE POINT WHERE GOCM IS BELIEVED TO HAVE UTILITY AND WILL BE TESTED FOR RELEVANCY, ACCURACY AND EASE OF USE ON THE LRB PROGRAM. SOON TO FOLLOW AS THE PROGRAM ADVANCES IN PHASE"A" AND/OR TRANSITIONS INTO PHASE "B" CERTAIN COST DRIVERS AND/OR COST ELEMENTS SENSITIVE TO DESIGN/PLANNING DECISIONS WILL REQUIRE GREATER CONFIDENCE IN THEIR ACCURACY. THESE ELEMENTS WILL REQUIRE EXAMINATION IN GREATER DETAIL AND THE EMPLOYMENT OF ENGINEERING ESTIMATES (ANALOGY). SELECT COST ELEMENTS WHICH ARE DEEMED VERY SENSITIVE AND SIGNIFICANT MAY TRANSITION EARLY TO DIRECT ENGINEERING AND DETAIL ESTIMATES. SUCH ELEMENTS MAY BE CRUCIAL TO BUDGET PLANNING AND/OR TRADE STUDIES. THESE TYPE ESTIMATES WILL BE CONDUCTED OUTSIDE THE GOCM MODEL AND WILL BE EVALUATED FOR INCORPORATION INTO GOCM AS A MODULE. SUCH MODULES HOWEVER, MAY NO LONGER BE TOTALLY PARAMETRIC IN NATURE. CAREFUL CONSIDERATION MUST BE GIVEN TO THE TECHNIQUES FOR INCORPORATION.

GENERATION OF SOFTWARE CHANGES WILL CONTINUE. THE DRAFT MANUAL WILL BE COMPLETED IN THE NEXT QUARTER. GENERATION OF THE SOFTWARE INSTRUCTIONS WILL COMMENCE LATE NEXT QUARTER.

GOCM IS A PARAMETRIC MODEL

- PHASE A COST ESTIMATING TOOL
- QUICK AND EASY TO USE ON A MACRO LEVEL
  - INPUTS ARE FUNDAMENTAL IN NATURE ie BOOSTER SIZE, GENERIC TYPE
  - FEW INPUTS REQUIRED
- PROVIDING GREATER SENSITIVITY TO DETAIL DESIGN FEATURES MAY LESSEN MODEL GENERALITY AND UTILITY
- TASK 9 EMPHASIS IS ON BOOSTER COST ACCURACY, COMPLETENESS, AND OVERALL MODEL UTILITY

TASK 9 OVERVIEW; APPROACH AND STATUS

LSOC TASK 9 IS ON SCHEDULE. HARDWARE, SOFTWARE AND PERSONNEL ARE IN PLACE AND ARE PROCEEDING QUICKLY FROM SOFTWARE, HARDWARE, AND PROGRAM FAMILIARITY TO THE COST/GOCM EVALUATION PHASE. COST ESTIMATING RELATIONSHIP (CER) DATA COLLECTION HAS BEEN INITIATED. WE WILL SOON INITIATE CER/MODEL MODIFICATIONS AND DEVELOPMENT. PRODUCT DEVELOPMENT IS IS ON TARGET. THE USER'S MANUAL IS MOVING TOWARDS COMPLETION OF THE FIRST DRAFT. A PRELIMINARY SET OF RECOMMENDATIONS IS IN PROCESS.

FUTURE EFFORTS ARE DIRECTED AT ASSESSING AND WHERE NECESSARY IMPROVING GOCM FOR LRB/SRB REALISM AND COMPLETNESS AND THE PREPARATION OF PRODUCTS.

LIQUID ROCKET BOOSTER INTEGRATION FIRST PROGRESS REVIEW

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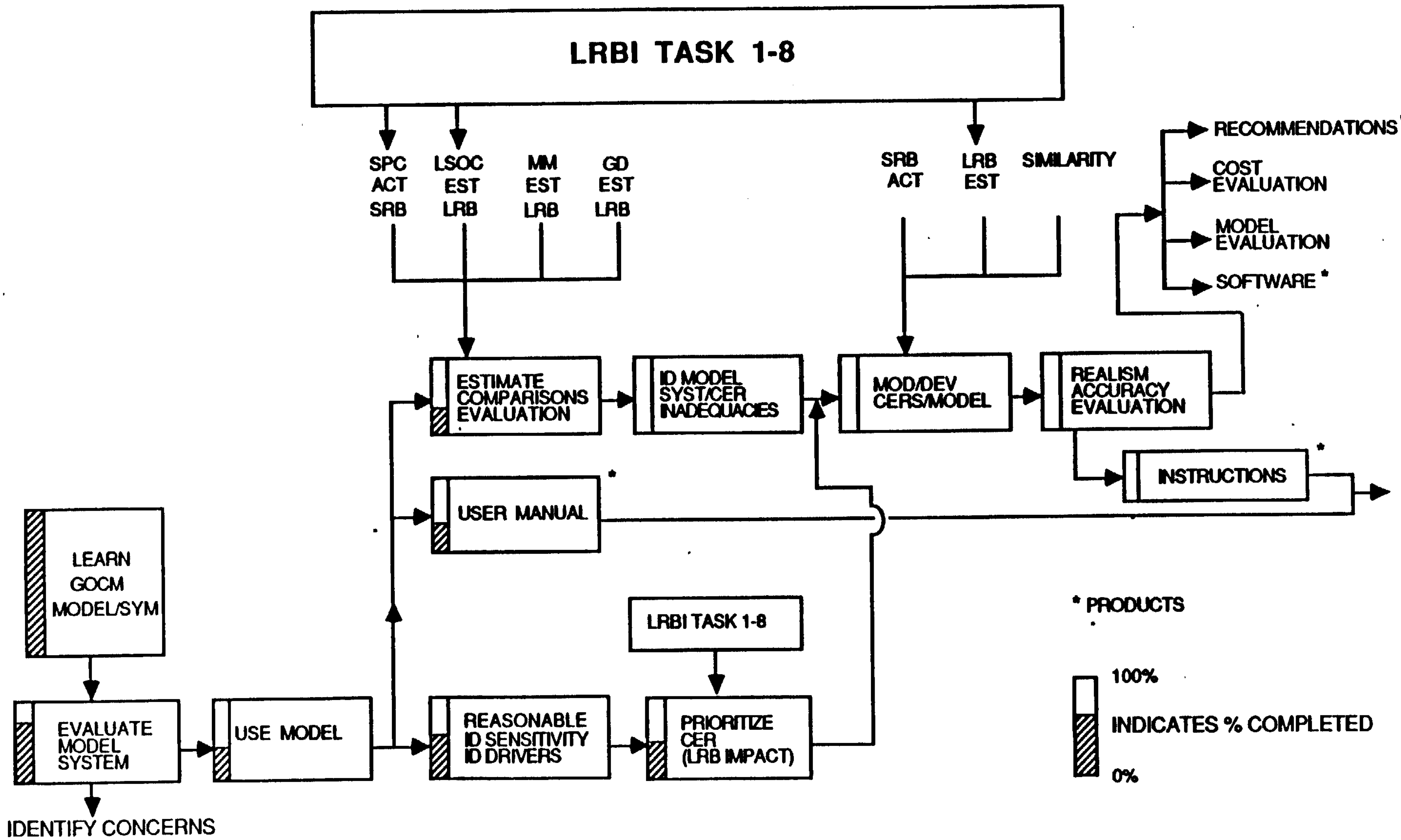

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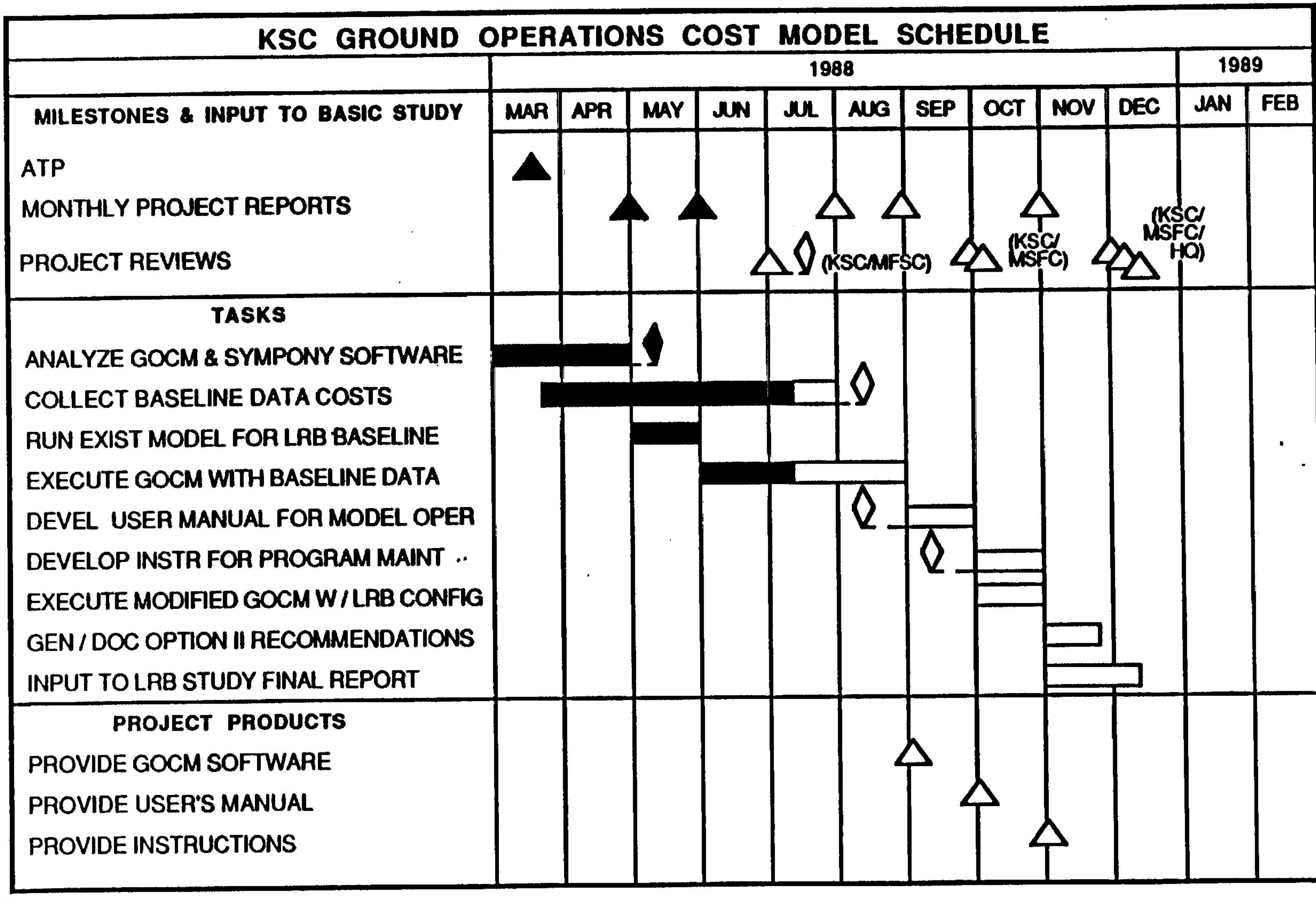


RESULTS OF MODEL EVALUATION

EVEN WITH THE COMPLETION OF THE GOCM USER'S MANUAL GOCM WILL REMAIN USER UNFRIENDLY. THE DISK OPERATING SYSTEM LIMITS THE MEMORY AVAILABLE TO SYMPHONY, WHICH MUST REMAIN RAM RESIDENT. ALTHOUGH EXPANDED MEMORY CARDS ARE AVAILABLE, MOST USERS DO NOT HAVE THEM INSTALLED. THIS REQUIRES GOCM TO BE ARBITRARILY (AND AWKWARDLY) PARTITIONED TO FIT IN STANDARD MEMORY.

CURRENTLY GOCM DOES NOT CONSIDER SHARING RESOURCES BETWEEN VARIOUS FLIGHT CONFIGURATIONS. FOR INSTANCE; THE RSRB PHASE OUT AND LRB PHASE IN CAN NOT BE CONSIDERED BY GOCM. THIS LIMITS GOCM UTILITY TO SINGLE VEHICLE OPERATIONS.

GSE AND FACILITY MODIFICATIONS ARE NOT CURRENTLY TAKEN INTO ACCOUNT IN GOCM. WITH THE ADVENT OF GROSS FACILITY MODIFICATIONS TO SUPPORT THE LRB, THE ABILITY FOR GOCM TO CONSIDER THEM IN LIEU OF REPLACEMENT IS DEEMED NECESSARY FOR ACHIEVING COST REALISM. ALTHOUGH SOME OF THE MODIFICATIONS MAY NOT INDIVIDUALLY BE CONSIDERED COST DRIVERS, COLLECTIVELY THEY MAY BECOME A SIGNIFICANT COST DRIVER.

GOCM DOES NOT PROVIDE SEGREGATED GROUND PROCESSING AND FACILITY COSTS FOR THE LRB/SRB STS ELEMENTS. THIS DOES NOT ALLOW EASY COMPARISON OF GOCM LRB/SRB GENERATED COSTS WITH THOSE DEVELOPED INDEPENDENTLY IN TANK 4.

RESULTS OF MODEL EVALUATION AND RECOMMENDATION

- GOCM IS A SOPHISTICATED MODEL
  - CONSISTANT RESULTS
  - REALISTIC COSTS
  - RELEVANT TO KSC GROUND PROCESSING
- RECOMMENDATIONS
  - EXPLORE SPREAD SHEET (SYMPHONY SOFTWARE) ALTERNATIVES
    - MORE EFFICENT USE OF HARDWARE
    - MORE USER FRIENDLY
  - EXPAND MODEL CAPABILITY TO CONSIDER MIXED FLEET SCENARIOS ie LRB / SRB / ASRM / ALS
  - ENHANCE MODEL TO REPORT SEGREGATED VEHICLE COSTS ie BOOSTERS, ET, ORBITER
  - ADD CERS FOR GSE / FACILITY MODIFICATIONS ie PAD, MLP CONFIGURATION CHANGES

EARLY IDENTIFIED COST CONCERNS

THE MLP WAS IDENTIFIED EARLY IN THE STUDY TO BE A SENSITIVE KSC COST DRIVER. TECHNICAL IMPACTS ARE STILL BEING ASSESSED FOR SOLUTIONS WHICH MAY SIGNIFICANTLY IMPACT SCHEDULE AND COSTS. ADDITIONAL REQUIRED DATA IS BEING GATHERED BEFORE THE ISSUE OF WHETHER TO BUILD NEW MLPS VERSUS MODIFICATION OF EXISTING MLPS IS ADDRESSED.

GOCM IS UNDER STUDY TO DETERMINE IF IT ADEQUATELY ADDRESSES NEW TYPE FACILITY COSTS, NONRECURRING FACILITY ACTIVATION COSTS, AND THE NONRECURRING GROUND PROCESSING TRANSITION COSTS.

DURING THE NEXT QUARTER TASKS 4 AND 9 WILL JOINTLY INVESTIGATE GROUND PROCESSING MANPOWER REQUIREMENTS. IT IS BELIEVED THAT THE MANPOWER ESTIMATES TO DATE ARE SUCCESS ORIENTED, AND MAY NOT BE REALISTIC. A SIMILAR FEAR EXISTS REGARDING LEARNING CURVES. HISTORICAL SHUTTLE PROCESSING DATA WILL BE EXAMINED AND AN EMPIRICAL LEARNING CURVE WILL BE DERIVED FOR EVALUATION AND POSSIBLE INCORPORATION INTO GOCM.

EARLY IDENTIFIED COST CONCERNS

- IDENTIFY MLP SENSITIVE COST DRIVERS - MOD VS NEW
- IDENTIFY NEW COST ELEMENTS:
  - HORIZONTAL PROCESSING FACILITY
  - GSE / FACILITY ACTIVATION COST
  - GROUND PROCESSING TRANSITION COST
- SUCCESS ORIENTED GROUND PROCESSING AND LEARNING CURVES MAY NOT BE SUBSTANTIATED BY ACTUAL DATA

KSC GOCM TOTAL STS LRB vs SRB COSTS

THE CURRENT GROUND OPERATIONS COST MODEL (GOCM) WAS USED TO ESTIMATE THE TOTAL STS COSTS AT KSC FOR THE CURRENT SRB BASELINE CONFIGURATION AND THE LRB BASELINE CONFIGURATION FOR RP1/LOX. THE SRB CONFIGURATION ASSUMED BASELINE TECHNOLOGY, PARACHUTE RECOVERABLE BOOSTERS, A PAYLOAD OF 65K LBS AND STS CONFIGURED FACILITIES. THE LRB CONFIGURATION ASSUMED ADVANCED TECHNOLOGY, EXPENDABLE BOOSTERS, A PAYLOAD OF 75K LRBS, AND NEW FACILITIES REQUIRED FOR PROCESSING CONSISTING OF: LRB PROCESSING, ET PROCESSING INTEGRATION BAY, AND MLP.

COMMON FACTORS CHOSEN FOR COMPARISON OF BOTH CONFIGURATIONS INCLUDED THE FOLLOWING:

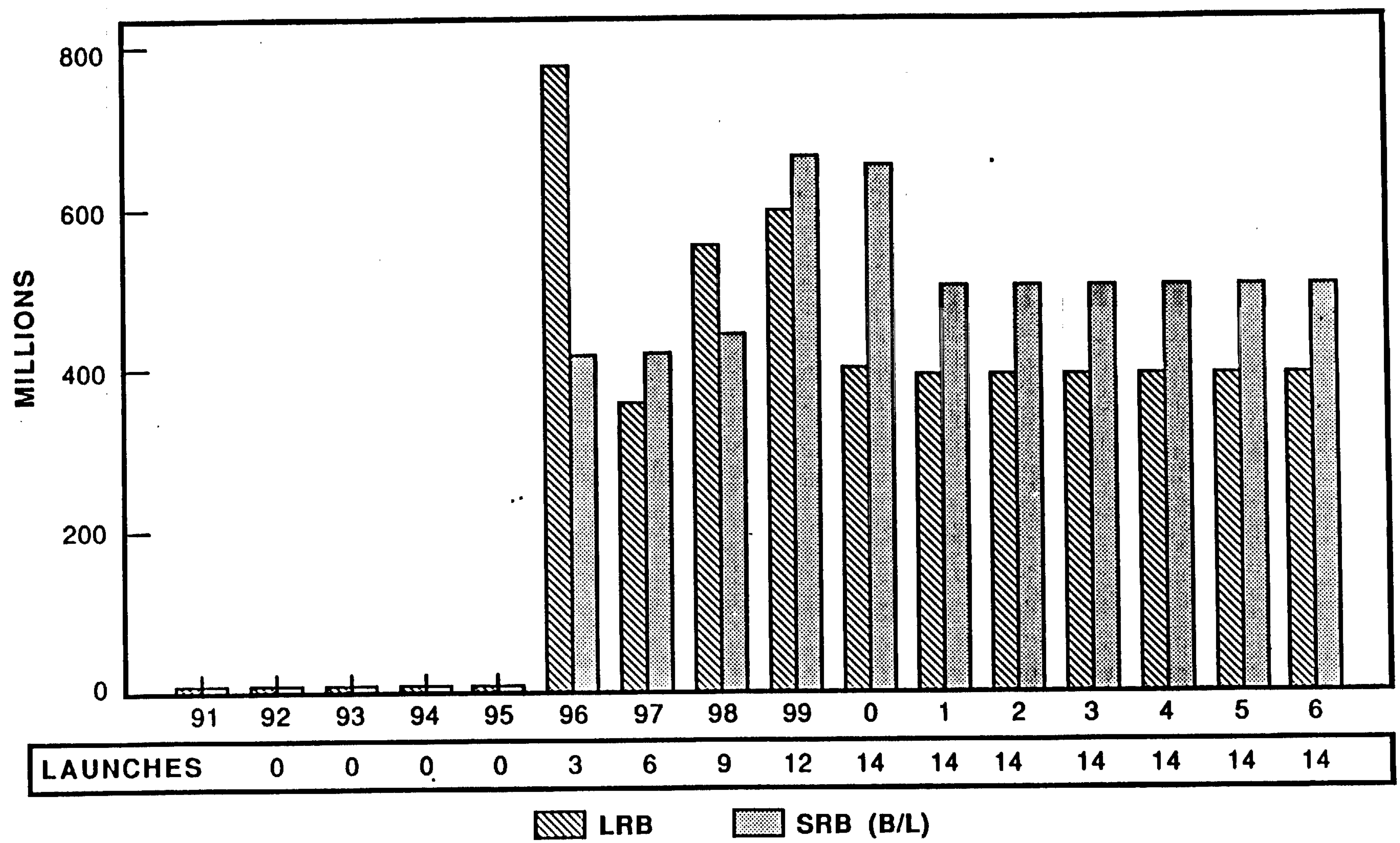
1. EITHER SRB OR LRB LAUNCHES (NO MIXED FLEET OPERATIONS).
2. NO LAUNCHES UNTIL 1996 WITH A RAMP RATE OF 3, 6, 9, 12, 14 ...
3. A FLIGHT HARDWARE SURGE FACTOR OF 15%.
4. ESCALATION RATE OF 0%
5. CONSTANT 1987$.
6. MANPOWER RATE OF $186 PER SHIFT.
7. WORK SCHEDULE OF 6 DAYS PER WEEK AT 3 SHIFTS PER DAY.
8. FACILITY UTILIZATION OF 85%.
9. NO LEARNING CURVE (100%).

IT CAN BE SEEN THAT COSTS ARE HIGHER FOR THE LRB CONFIGURATION AT FIRST DUE TO THE NEW FACILITIES REQUIRED TO SUPPORT LAUNCH. AS THE LAUNCH RATE INCREASES SECOND AND/OR THIRD LINE FACILITIES ARE ADDED TO SUPPORT BOTH LRB AND SRB CONFIGURATIONS. STEADY STATE COSTS ARE ACHIEVED AS STEADY STATE LAUNCHES OCCUR IN THE YEAR 2001. TOTAL COSTS ARE LESS FOR THE LRB CONFIGURATION DUE TO SHORTER PROCESSING TIMES AND ARE NOT SENSITIVE TO BOOSTER RECOVERY COSTS.

LIQUID ROCKET BOOSTER INTEGRATION FIRST PROGRESS REVIEW

JULY 1988

KSC GOCM - TOTAL STS SRB VS LRB COSTS



80708-01S

Lockheed Space Operations Company

KSC GOCM - STS DELTA LRB VS SRB COSTS

AS NOTED PREVIOUSLY, ONCE STEADY STATE LAUNCHES ARE ACHIEVED IN THE YEAR 2001, LRB BOOSTERS WOULD BE LESS EXPENSIVE TO OPERATE AT KSC BY APPROXIMATELY 100 MILLION DOLLARS PER YEAR. HOWEVER, DURING THE START UP YEARS, BETWEEN 1995 THROUGH 2000, VARIOUS FACILITIES ARE COMING ON LINE AND ADDING COSTS AT KSC. THE FOLLOWING IS A BREAKDOWN OF FACILITIES REQUIRED TO SUPPORT THE LAUNCH RATE MODEL FOR EITHER LRB OR SRB CONFIGURATION:

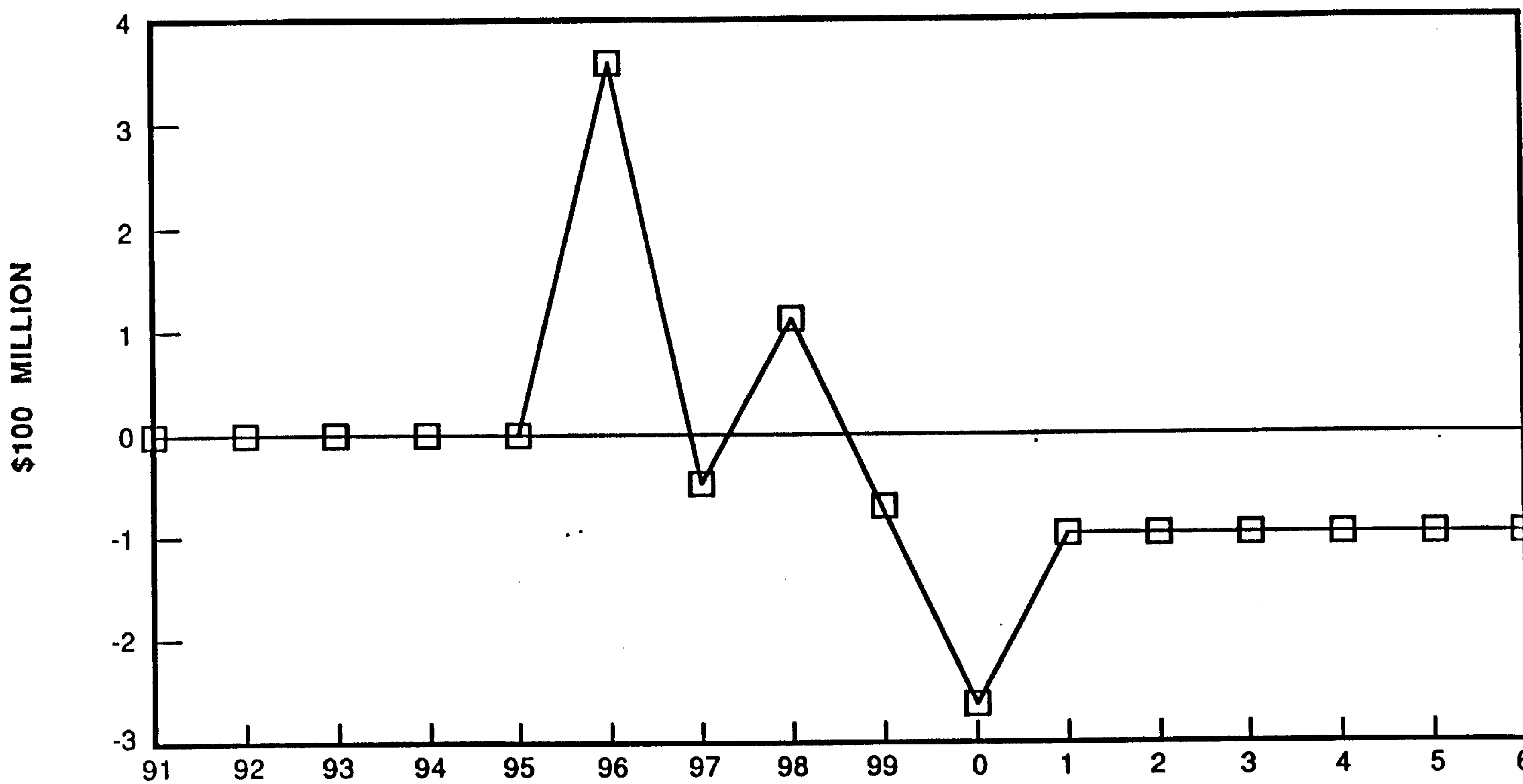
1996	LRB	A NEW LIQUID BOOSTER C/O BAY, TO SUPPORT LRB PROCESSING. A NEW ET CHECKOUT FACILITY TO MAKE ROOM FOR A NEW INTEGRATION BAY. A NEW INTEGRATION BAY. A NEW MLP
	SRB	NO FACILITIES REQUIRED.
1997	LRB	NO FACILITIES REQUIRED.
	SRB	NO FACILITIES REQUIRED.
1998	LRB	A SECOND MLP.
	SRB	NO FACILITIES REQUIRED.
1999	LRB	A SECOND VEHICLE INTEGRATION BAY.
	SRB	A THIRD VEHICLE INTEGRATION BAY.
2000	LRB	A SECOND LIQUID BOOSTER C/O BAY.
	SRB	A FORTH MLP.

NOTE: THE CURRENT MODEL DOES NOT CONSIDER MODIFICATIONS. THEREFORE, THE LAUNCH PADS ARE NOT TAKEN INTO ACCOUNT.

LIQUID ROCKET BOOSTER INTEGRATION FIRST PROGRESS REVIEW

JULY 1988

KSC GOCM - STS DELTA LRB VS SRB COSTS



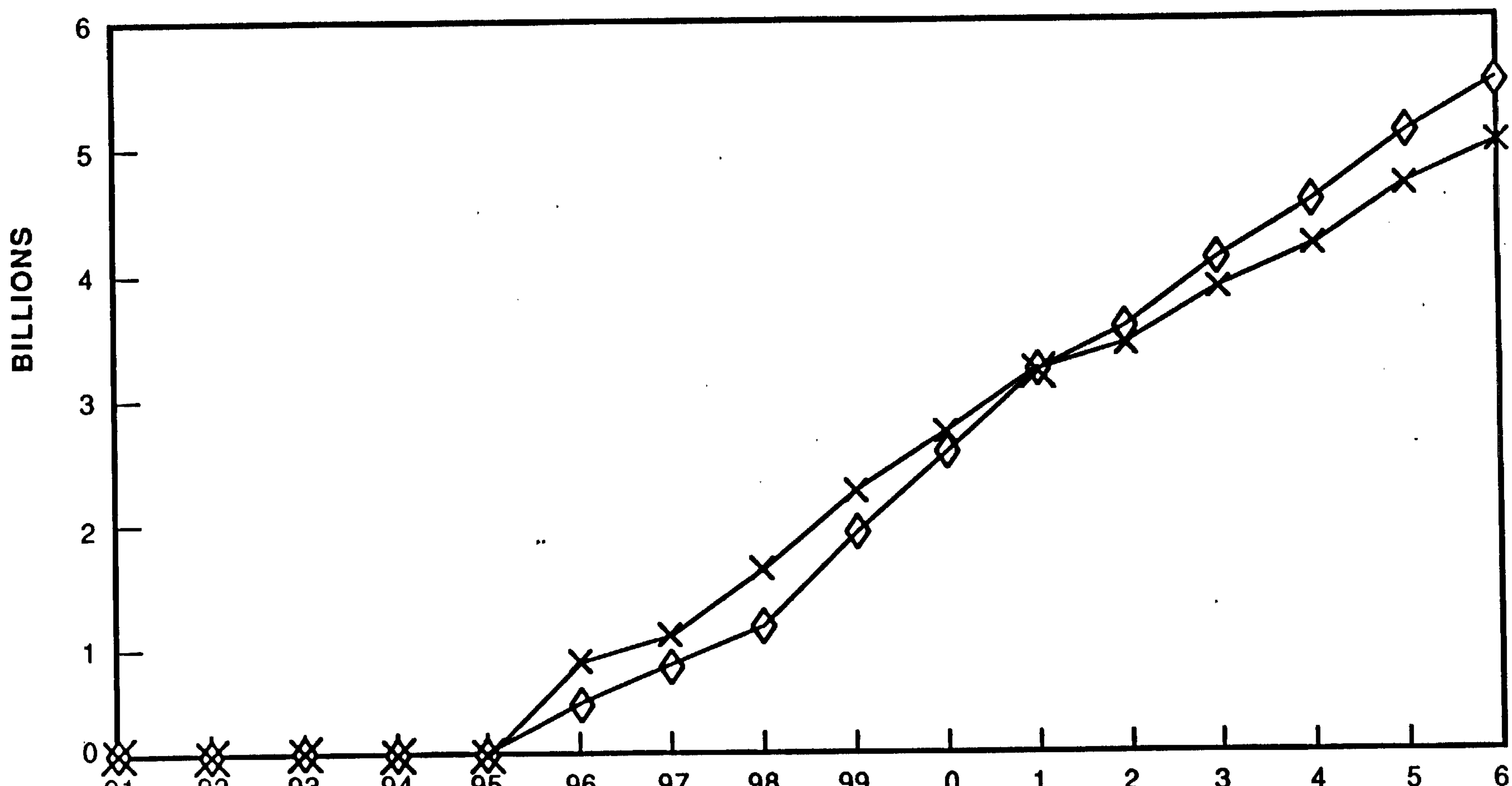
LAUNCHES	0	0	0	0	3	6	9	12	14	14	14	14	14	14	14

LRB MINUS SRB

KSC GOCM - LRB vs SRB CUMULATIVE COSTS

CUMULATIVE COSTS HAVE BEEN PLOTTED FOR LRB AND SRB LIFE CYCLE COSTS AT KSC. ACCORDING TO THE GROUND OPERATIONS COST MODEL, THE LRB FLEET WOULD BE MORE COSTLY DURING THE FIRST HALF OF THE PROGRAM UNTIL THE YEAR 2000 OR AFTER 51 LAUNCHES. THE LRB FLEET WOULD THEN YIELD A COST SAVINGS OVER THE SRB FLEET OF APPROXIMATELY 500 MILLION DOLLARS AFTER 128 LAUNCHES THROUGHOUT THE REMAINING LIFE OF THE PROGRAM.

KSC GOCM - TOTAL STS LRB VS SRB CUM COSTS



LAUNCHES	0	0	0	0	3	6	9	12	14	14	14	14	14	14	14

COMPARATIVE AND SOURCE DATA COLLECTION (2ND ITERATION)

SPC GROUND PROCESSING DATA IS BEING COLLECTED. THIS INCLUDES THE EXAMINATION OF KSC/WBS AND ORGANIZATIONAL DATA WHICH WILL BE USED TO ALLOCATE/VERIFY THE PAST BUDGETARY/FISCAL EXPENDITURES. ADDITIONAL GSE/FACILITY COST TO PROCESS THE NEW BOOSTER CONFIGURATIONS ARE BEING DEVELOPED THROUGH THE REVIEW OF SIMILAR EXISTING ITEM AND THEIR COSTS, COMPLEXITY FACTORS, DOLLARS PER FT^3 OR FT^2, OTHER EXTRAPOLATION TECHNIQUES, AND ENGINEERING BUDGETARY COST ESTIMATES. COST ESTIMATES FOR SIGNIFICANT GSE/FACILITY MODIFICATIONS ARE BEING DEVELOPED IN A MANNER SIMILAR TO THAT DESCRIBED ABOVE.

COMPARATIVE AND SOURCE DATA COLLECTION

- CALIBRATE GOCM ACCURACY AND COMPLETENESS
  - ANALYSIS OF KSC WBS AND ORGANIZATIONAL DATA TO ALLOCATE AND VERIFY EXISTING MANPOWER RESOURCES
  - REQUIRED ADDITIONAL GSE / FACILITY COSTS TO PROCESS NEW VEHICLE CONFIGURATIONS ARE BEING DEVELOPED
  - COST ESTIMATING FOR SIGNIFICANT GSE / FACILITY MODIFICATIONS IS UNDERWAY

AGENDA

I. INTRODUCTION	GORDON ARTLEY
II. STUDY PROGRESS	
A) LRB PROJECT INTEGRATION	PAT SCOTT
B) BASELINE REQUIREMENTS	KEITH HUMPHRYES
C) IMPACT ANALYSIS	GREG DEBLASIO
D) PLANS, PRODUCTS AND MODEL	JERRY LEFEBVRE
III. SUMMARY	GORDON ARTLEY

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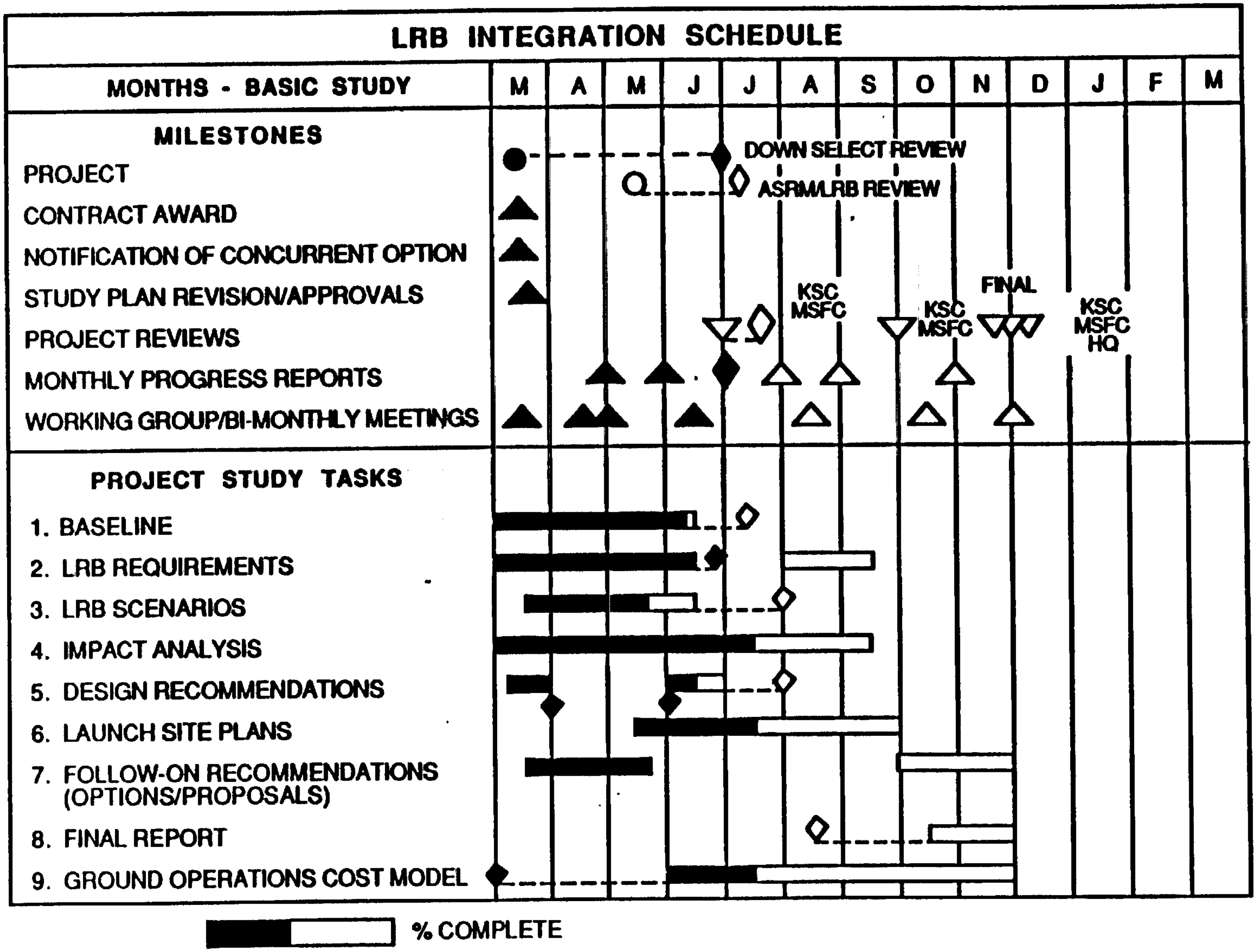
KSC ADVANCED PROJECTS & TECHNOLOGY OFFICE

LIQUID ROCKET BOOSTER INTEGRATION FIRST PROGRESS REVIEW

JULY 1988



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Lockheed Space Operations Company

LRB PROJECT INTEGRATION

ALTHOUGH THE MSFC CONTRACTORS HAVE COMPLETED THE FINAL REPORT FOR THEIR PORTION OF THE STUDY, THEY HAVE RECEIVED A SIX-MONTH EXTENSION. THE WORKING GROUP INTEGRATION WILL THEREFORE CONTINUE THROUGH DECEMBER. THE KSC STUDY WILL REQUIRE MAJOR REVISION TO ACCOMMODATE FURTHER DOWN-SELECTION AND/OR UP-SELECTION. THE EXPENDABLE BOOSTER HAS BEEN BASELINED AT THIS TIME. THE WORKING GROUP HAS EXPRESSED TECHNICAL AND COST CONCERN WITH THIS DECISION. THE PRE-INTEGRATION PROCESS OF THE LRB RELIES ON THE SHIPPING CONFIGURATION. ADDITIONAL BASELINING IS REQUIRED TO EVALUATE THE IMPACT OF "SHIP TO SHOOT" OR SUBASSEMBLY SCENARIOS. THE TRANSITION TO THE LRB REMAINS THE MOST SIGNIFICANT DRIVER TO KSC. THE SYNERGISTIC EFFECT OF FUTURE MULTIPLE PROGRAMS HAS NOT YET BEEN FULLY EVALUATED IN LIGHT OF ASRM, ALS, SHUTTLE C AND SHUTTLE DERIVATIVES. COORDINATION WITH THE WORKING GROUP WILL CONTINUE THROUGH THE REMAINDER OF THIS YEAR. NEXT PERIOD THE LAUNCH PROCESSING SCENARIOS WILL BE FINALIZED. THESE SCENARIOS WILL BE TAILORED TO THE SIX BOOSTER OPTIONS AND THE OPTIMUM FACILITY/GROUND SYSTEMS CONFIGURATIONS. ADDITIONAL DATABASE WILL ENABLE MORE REFINED AND AUTOMATED COST ESTIMATING TO ENHANCE COST/BENEFIT ANALYSES.

LIQUID ROCKET BOOSTER INTEGRATION FIRST PROGRESS REVIEW

LRB PROJECT INTEGRATION

STATUS: THE PROJECT INTEGRATION IS COMPLETED FOR THE MFSC PHASE A STUDY. HOWEVER, THIS FUNDING WILL CONTINUE FOR ANOTHER SIX MONTHS VIA THE WORKING GROUP

WORKING GROUP ISSUES:

- FORMALIZE BASELINES FOR CONFIGURATION OPTIONS TO PROVIDE CONTROL OF REVISIONS
- RECOVERY / REUSE VS EXPENDABLE
- INTERFACE OF THE ELEMENT CONTRACTOR WITH LAUNCH SITE
- TRANSITION PLANNING TO SUPPORT DDT&E
- MIXED FLEET INTEGRATION AT LAUNCH SITE

NEXT PERIOD PLANS:

- COORDINATION WITH THE WORKING GROUP ACTIONS
- FINALIZE THE LAUNCH SITE SCENARIO REQUIREMENTS
- REFINE COST ASSESSMENTS

LRB BASELINE REQUIREMENT

THE TEST TEAM WILL JOINTLY EVALUATE THE COMBINATION OF REQUIREMENTS, FACILITIES/GROUND SYSTEMS AND PROCESSING PROCEDURES ESSENTIAL TO EACH OPTION CONFIGURATION. THE BASELINE PARAMETERS MUST BE FROZEN IN ORDER TO GENERATE THE FINAL PRODUCT. THIS PRECLUDES MAJOR MODIFICATIONS TO THE PROCESSING SCENARIO OR FACILITIES. THE ULTIMATE ELEMENT CONTRACTOR MAY HAVE AN OPTION TO FINALIZE ASSEMBLY AND CHECKOUT OF THE LRB AT OR NEAR KSC. THIS REQUIREMENT WOULD APPRECIABLY ALTER THE SCENARIO OF THE PRE-INTEGRATION PROCESSING. DURING THE ENSUING PERIOD THE REQUIREMENTS DATA WILL BE CONSOLIDATED BY CONFIGURATION OPTION AND SCREENED FOR INCORPORATION INTO THE APPROPRIATE 16 PRODUCTS. THE SCENARIO EFFORT WILL FOCUS ON THE FINALIZATION OF THE TIMELINES AND THE PROCESSING MANPOWER FOR EACH OF THE CONFIGURATION OPTIONS.

LRB BASELINE REQUIREMENT

STATUS: THE BASELINE, REQUIREMENTS AND SCENARIOS TASKS ARE UNDER FULL TEAM REVIEW TO INCORPORATE THE FINAL BOOSTER OPTIONS

CONCERNS: GENERATION OF NEW OR REVISED REQUIREMENTS FROM MFSC EXTENDED PHASE A STUDIES AND PROGRAM WORKING GROUP

CONCEPT FOR LRB ON-SITE ELEMENT CONTRACTOR AT OR NEAR KSC FACILITIES / ACTIVITIES

PLANS: INTEGRATION AND REFINEMENT OF BOTH CURRENT AND ADDITIONAL DATA INTO FINALIZED PRODUCTS

INCORPORATE TIMELINES AND PROCESSING MANPOWER INTO SCENARIOS

IMPACT ANALYSIS

USING THE LOX/RP-1 CONFIGURATION OPTIONS AS A BASELINE, A SERIES OF TRADE STUDIES ARE NEARING COMPLETION. THESE STUDIES INCLUDE ANALYSIS ACROSS ALL STATION SETS. THE PRINCIPAL EFFORT HAS BEEN TO ADDRESS THE MAJOR FACILITIES AND GROUND SYSTEMS. THE INITIAL COST DATA HAS BEEN DERIVED ALONG WITH ENVIRONMENTAL AND SAFETY INFLUENCES. CONSIDERABLE CONCEPT DATA HAS BEEN CRAFTED FOR NEW AND MODIFIED PROPELLANT STORAGE HANDLING/TRANSFER SYSTEMS. THIS DATA WILL BE AUGMENTED TO APPLY TO EACH OF THE CONFIGURATION OPTIONS. LRB TRANSITION DURING AN ON-GOING 14-FLIGHT PER YEAR SHUTTLE PROGRAM PRESENTS TWO PARAMOUNT CONCERNS. THERE IS NO AVAILABLE TIME FOR A REQUIRED LRB ACTIVATION PROGRAM. IN ADDITION, ALL USABLE LAUNCH FACILITIES ARE FULLY COMMITTED TO THE CURRENT MISSION. THE BOOSTER DIAMETER AND LENGTH HAVE IMPOSED EXCESSIVE MANDATES ON THE CONFIGURAITON OF THE MLP, UMBILICALS/SWING ARMS, ACCESS PLATFORMS AND DEFLECTORS/FLAME TRENCH. THE IMPACT ANALYSIS FOR ALL STATION SETS WILL BE COMPLETED BY MID-SEPTEMBER. THE DETAIL DATA CREATED WILL BE THE FOUNDATION OF THE 16 DELIVERABLE PRODUCTS.

IMPACT ANALYSIS

STATUS: THE MAJOR IMPACTS TO FACILITIES AND LSE HAVE BEEN IDENTIFIED AND BASELINED FOR FINAL ANALYSIS AND RECOMMENDED SOLUTIONS

ISSUES:
IMPACTS TO SHUTTLE MANIFEST
LRB TRANSITION VS AVAILABLE MOD AND ACTIVATION PERIODS
BOOSTER DIAMETER
BOOSTER LENGTH
DEFLECTOR / FLAME TRENCH
PAD BOOSTER ACCESS
STAND-ALONE PROCESSING

NEXT PERIOD PLANS: FINALIZE THE IMPACTS AND DESIGN APPROACHES FOR ALL STATION SETS AND DELTA FOR ALL OPTIONS

PLANS, PRODUCTS AND MODEL

THE GOCM STUDY IS ON SCHEDULE. THE USERS MANUAL IS IN PROCESS. SOFTWARE ADEQUACY HAS BEEN INVESTIGATED AND MODIFICATIONS ARE IN PROCESS, PRELIMINARY GOCM COST ESTIMATES HAVE BEEN PRODUCED. GOCM COST ESTIMATING RELATIONSHIPS (CERS) MUST BE ANALYZED FOR ACCURACY AND COMPREHENSIVENESS. THE ESTABLISHMENT AND CONFIRMATION OF AN HISTORICAL DATABASE IS ESSENTIAL FOR THE TRANSLATION OF PAST DATA TO FUTURE PLANS. THE COST TO BOTH SINGLE FLIGHT ELEMENTS AND THE IMPACT OF MODIFICATIONS/ACTIVATION TO REQUIRED FACILITIES/GROUND SYSTEMS WILL BE REFLECTED IN LIGHT OF NASA PROGRAMS. THIS DATA WILL BE CORRELATED WITH THE LRB STUDY ASSESSMENTS.

PLANS, PRODUCTS AND MODEL

STATUS:	GOCM AND SYMPHONY SOFTWARE ANALYSIS COMPLETE BASELINE DATA COLLECTION IN PROCESS GOCM LRB BASELINE COST ESTABLISHED BY RUNNING EXISTING MODEL
CONCERNS:	EVALUATION OF COST ESTIMATING RELATIONSHIPS WITH HISTORICAL DATA
NEXT PERIOD PLANS:	ASSEMBLAGE AND EXTRAPOLATION OF HISTORICAL DATA GENERATION OF DRAFT PLANS AND PRODUCTS

VOLUME IV

SECTION 6

SECOND PROGRESS REVIEW

October 14, 1988

LIQUID ROCKET BOOSTER INTEGRATION SECOND PROGRESS REVIEW

OCT 1988

AGENDA

I. INTRODUCTION	Gordon Artley
II. STUDY PROGRESS	
A. ACHIEVEMENT SUMMARY	Pat Scott
B. ENGINE PROCESSING STUDY	Glen Waldrop
C. LRB/ET PROCESSING EVALUATION	Greg DeBlasio
D. SAFETY & ENVIRONMENTAL IMPLICATIONS	Roger Lee
E. GOCM STATUS	Stephen Schneider
III. SUMMARY	Gordon Artley

PLANNED WORK

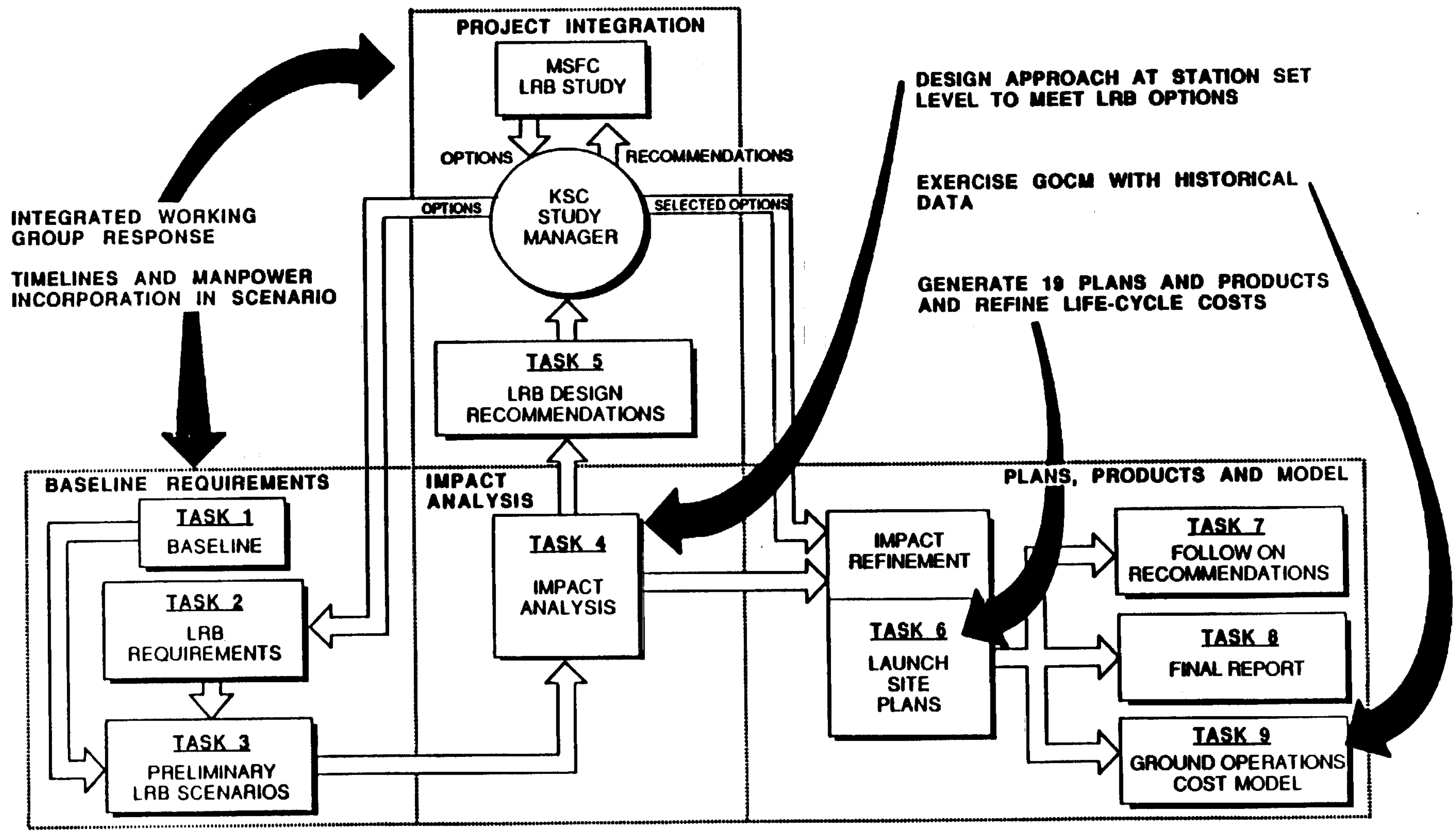
AT THE 1ST PROGRESS REVIEW (JULY), THE FOLLOWING WORK PLAN WAS PRESENTED FOR THE SECOND PERIOD:

1. CONTINUE TO SUPPORT AND RESPOND TO THE INTEGRATED WORKING GROUP
2. REFINE GROUND PROCESSING SCENARIOS AND INCORPORATE TIMELINES AND PROCESSING MANPOWER
3. CONTINUE THE IMPACT/ANALYSIS AND DESIGN APPROACH FOR ALL STATION SETS TO MEET LRB OPTION
4. ASSEMBLE APPROPRIATE HISTORICAL DATA AND EXERCISE/CALIBRATE THE COST MODEL
5. GENERATE PLANS AND PRODUCT DRAFTS
6. REFINE LIFE-CYCLE COSTS AND PREPARE DETAIL STATION SET LEVEL COST ESTIMATES

LIQUID ROCKET BOOSTER INTEGRATION
SECOND PROGRESS REVIEW

OCT 1988

SECOND PERIOD WORK PLAN



IN ORDER TO PROVIDE A STATUS, THE FOLLOWING SIGNIFICANT SUBJECTS WILL BE ADDRESSED:

FIRST, WE HAVE EVALUATED THE MOST RECENT LRB CONFIGURATIONS AND ASSESSED THEIR IMPACT TO THE PROCESSING SCENARIO. SECOND, WE HAVE EXPANDED THE LAUNCH SITE SCENARIOS TO INCLUDE THE TRANSITION PLAN FOR PHASING IN LRBS. THIRD, WE HAVE MODIFIED THE PROCESSING FLOW TO MEET THE LATEST LRB REQUIREMENTS. FOURTH, WE HAVE PROVIDED A SUMMARY OF THE INFLUENCES OF THE LRB WORKING GROUP'S WORK ON ASCENT AND ABORT PERFORMANCE, LAUNCH TOWER CLEARANCE AND VEHICLE EXCURSION. IN ADDITION, WE WILL REVIEW THE WORKING GROUPS ANALYSIS OF LRB APPLICATIONS TO ALTERNATE VEHICLES, AND THE IMPACT TO GROUND PROCESSING.

SELECT TOPICS HAVE BEEN CHOSEN TO REVEAL KEY ISSUES AND IMPACTS. FIRST, AN LRB PROCESING ASSESSMENT HAS SHOWN THE SIGNIFICANCE OF PROVIDING AN INTEGRATED VEHICLE WITH 11 LIQUID ENGINES VERSUS THE CURRENT 3. SECOND, THE INTEGRATION OF HI-BAY 4 FOR LRB INTEGRATION WILL PROVIDE THE FIRST IN A SERIES OF INFLUENCES TO DECENTRALIZE BOTH THE LRB AND THE ET PRE-INTEGRATION PROCESSING. THIRD, WE HAVE RECOGNIZED THE SIGNIFCANT SAFETY AND ENVIRONMENTAL IMPLICATION TO LRB PROCESSING THAT COULD BE AN IMPORTANT COST CONSIDERATION, A TIME INFLUENCE AND A DESIGN DRIVER. FOURTH, THE SENSITIVITY OF LRB TO COST HAS HIGHLIGHTED THE IMPORTANCE OF THE DEVELOPMENT OF THE GROUND OPERATIONS COST MODEL AND ITS APPLICATION TO LRB.

STUDY PROGRESS

STATUS SUMMARY

- BASELINE, SCENARIO AND WORKING GROUP INFLUENCES

SELECTED STUDY TOPICS

- LRB ENGINE PROCESSING ASSESSMENT
- ET AND LRB PROCESSING IMPACTS
- SAFETY AND ENVIRONMENTAL IMPLICATIONS
- GROUND OPS COST MODEL DEVELOPMENT

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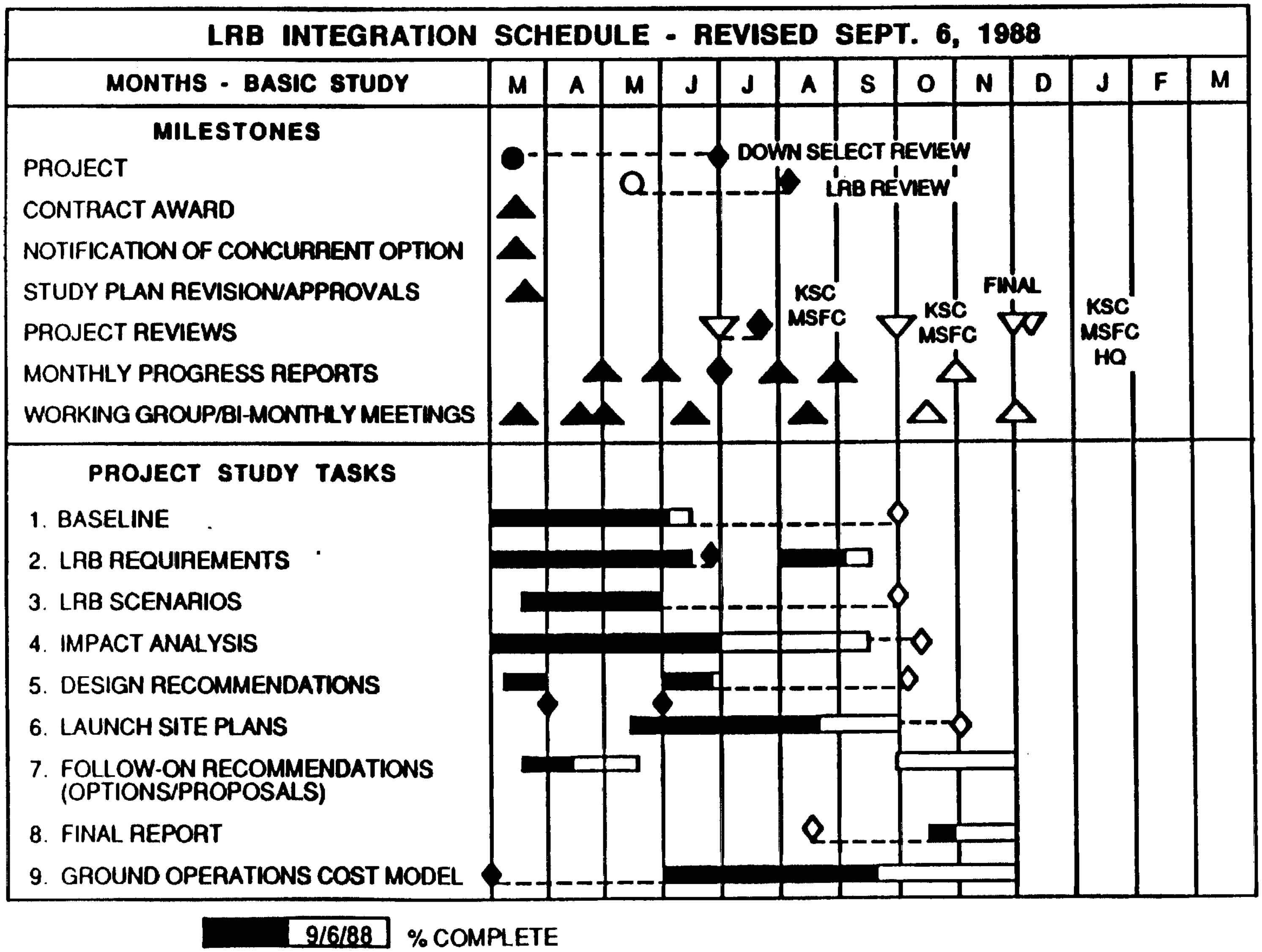
LIQUID ROCKET BOOSTER INTEGRATION SECOND PROGRESS REVIEW

OCT 1988



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LIQUID ROCKET BOOSTER INTEGRATION SECOND PROGRESS REVIEW

OCT 1988

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A. ACHIEVEMENT SUMMARY

1. STUDY BASELINE ASSESSMENT
2. LRB TECHNICAL WORKING GROUP ACTIVITIES
3. ALTERNATE LRB APPLICATIONS

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LIQUID ROCKET BOOSTER INTEGRATION SECOND PROGRESS REVIEW

OCT 1988

1. STUDY BASELINE ASSESSMENT

- LRB CONFIGURATION UPDATE
  - LRB PROPOSED ENGINE POSITIONS
- BASELINE LAUNCH SITE SCENARIO
  - TRANSITION PLAN OVERVIEW
- LRB PROCESSING FLOW UPDATE

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LIQUID ROCKET BOOSTER INTEGRATION SECOND PROGRESS REVIEW

OCT 1988

LRB CONFIGURATION UPDATE

- MSFC LRB STUDIES
  - MARTIN (2): LOX/RP-1 PUMP-FED/PRESSURE-FED
  - GENERAL DYNAMICS (3): LOX/RP-1 PUMP/PRESSURE
LOX/LH2 PUMP-FED
- FINAL REPORT PRESENTATION: JUNE 88
- MSFC CONTRACTS EXTENDED TO JAN 89
  - CONTINUING CONFIGURATION REFINEMENTS

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SUMMARY OF LRB PHASE A FINDINGS (REF. GDSS/MMC)

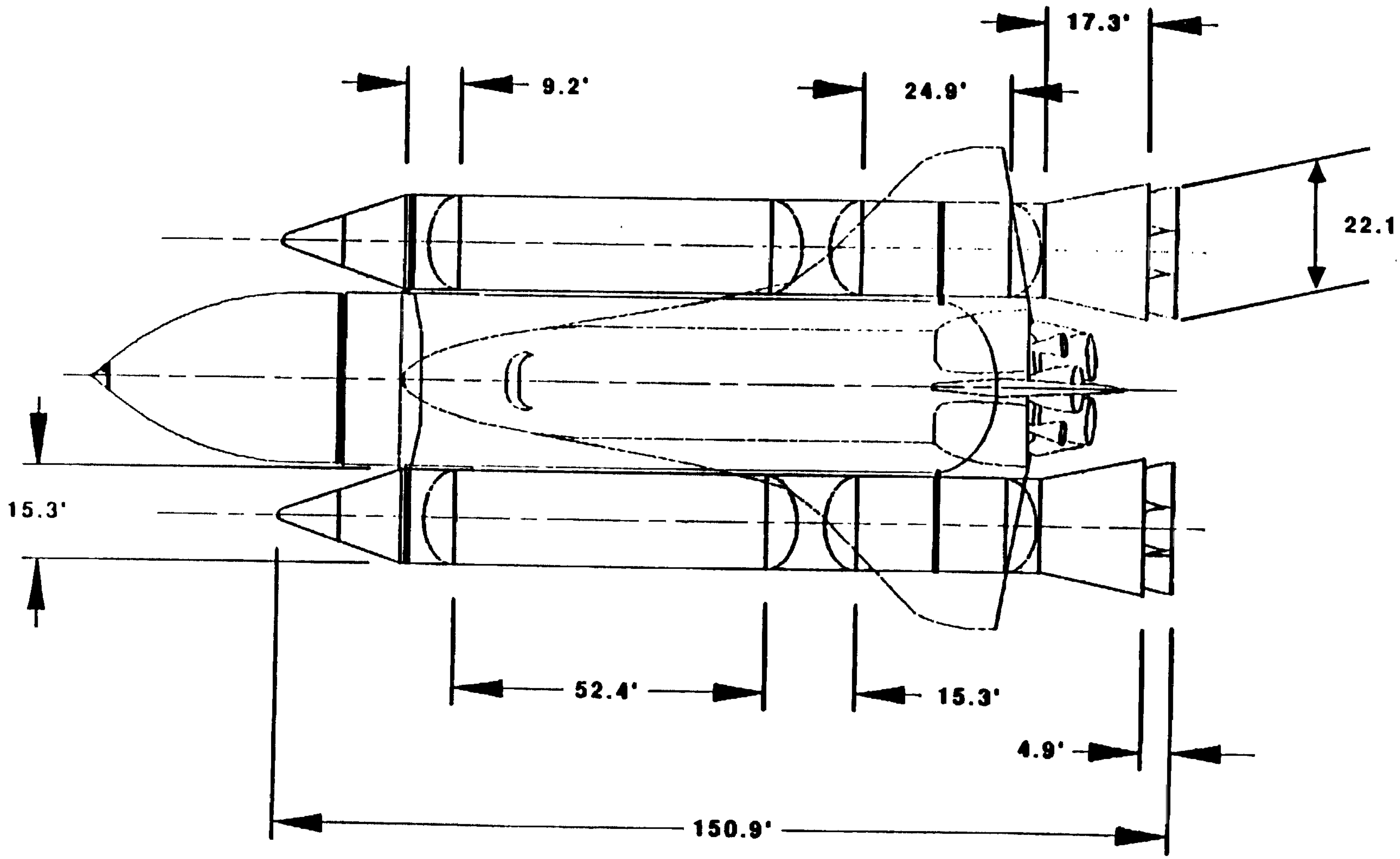
- LRB SHOULD BE EXPENDABLE BOOSTER
- ALL CONFIGURATIONS ARE 4-ENGINED
- NEW LOW-COST ENGINE DEVELOPMENT REQUIRED
- LOX/RP-1 IS FAVORED PROPELLANT
- BOTH PUMP AND PRESSURE-FED OPTIONS ARE VIABLE (PRESSURE-FED REQUIRES TECHNOLOGY DEVELOPMENTS)
- ALL SELECTED CONFIGURATIONS CAN BE FLOWN WITHIN CURRENT STS CONSTRAINTS
- LRB WILL IMPACT KSC "MODERATELY"

LRB CONFIGURATION UPDATE

MARTIN MARIETTA

- PUMP-FED CONFIGURATION HAS REMAINED UNCHANGED. DUAL 17-INCH FEED LINES ROUTE THE LOX AROUND THE RP-TANK. FORWARD THRUST ATTACH POINT IS LOCATED IN LRB FORWARD SKIRT AREA. AFT ATTACH IS IN MID-TANK AREA WHERE LOWER TRANSVERSE LOADS ARE DISTRIBUTED THROUGH A DEEP RING STIFFENER WITHIN THE TANK. DIAMETER AND LENGTH DIMENSIONS ARE CLOSEST TO SRB.

Pump-Fed - LO2/RP1



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Vehicle Configuration Summary - Pump-Fed 6/16/88

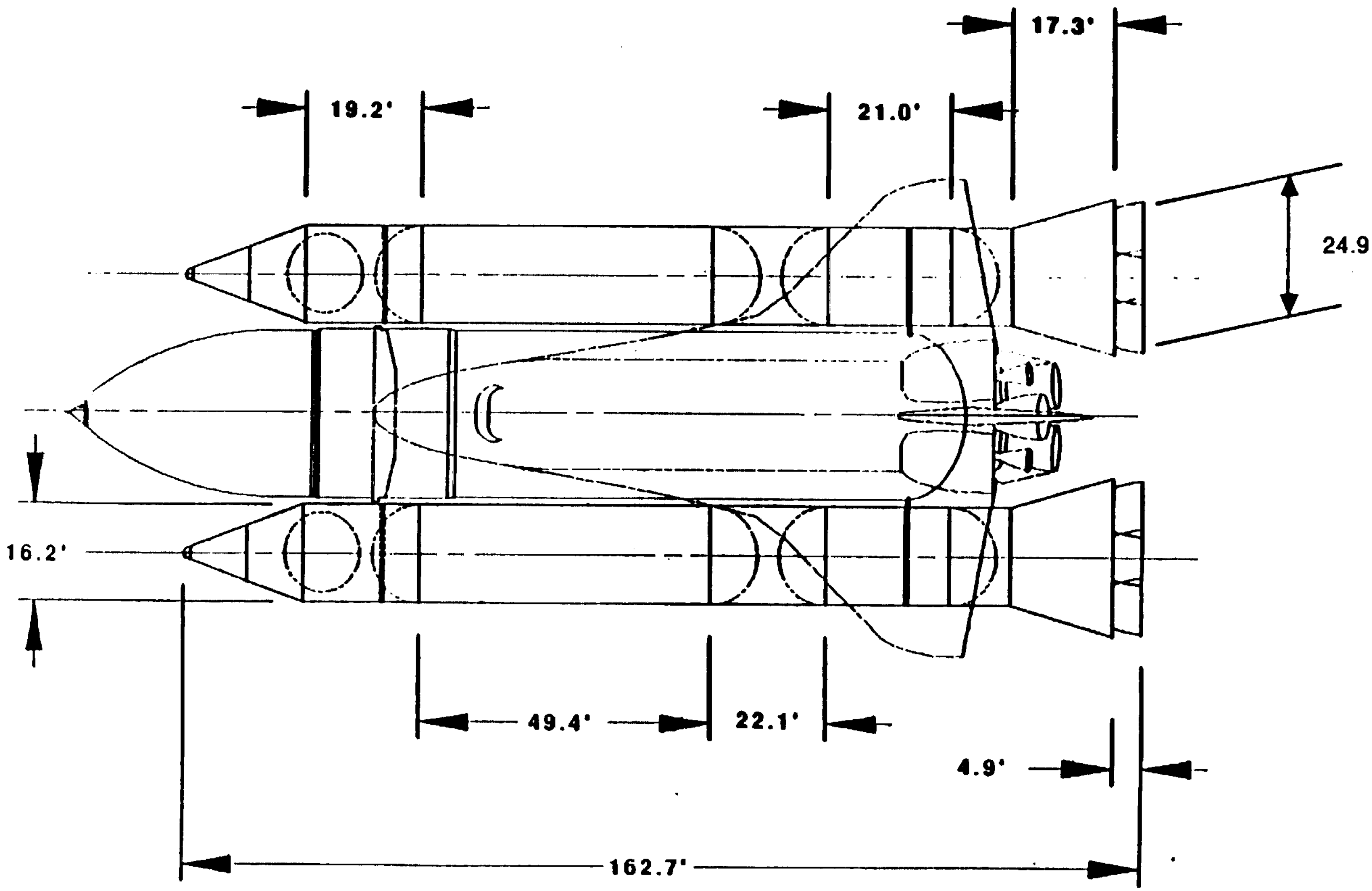
Vehicle Dimensions	
Length (in)	1,810.7
Diameter (OD - in)	183.0
Engine Exit Area (in^2)	7,359
Propellant Tank Volumes (Ft^3)	
LO2	10,769
RP-1	5,796
Weight (lb)	
Structure	73,500
Propulsion System	33,410
Other Subsystems	9,695
Inert Weight	116,665
Usable Impulse Propellant	
LO2	701,302
RP-1	268,698
Residuals Gases and Liquids	5,335
Glow	1,092,000

LRB CONFIGURATION UPDATE

MARTIN MARIETTA

- PRESSURE-FED CONFIGURATION IS SIGNIFICANTLY LARGER. TANK WALL THICKNESSES ARE APPROXIMATELY 1-INCH. ENGINE CHAMBER PRESSURE OF 800 PSI REQUIRE TANK PRESSURE OF 1000 PSI AND PRESSURIZATION SYSTEM OF 3000 PSI. HIGHER PROPELLANT LOADING INCREASES GROSS LIFT OFF WEIGHT TO 1.3 M POUNDS WHICH IS HEAVIER THAN CURRENT SRB. HIGHER ENGINE THRUST IS REQUIRED (APPROXIMATELY 750K EACH.) RESULTING IN 3M LBS PER BOOSTER)

Pressure-Fed - LO2/RP1



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ADVANCED PROGRAMS

Vehicle Configuration Summary - Pressure-Fed 6/16/88

Vehicle Dimensions	
Length (in)	1,952.0
Diameter (OD - in)	194.0
Engine Exit Area (in^2)	9,365
Propellant Tank Volumes (Ft^3)	
LO2	12,012
RP-1	6,328
Weight (lb)	
Structure	143,160
Propulsion System	44,030
Other Subsystems	12,330
Inert Weight	199,520
Usable Impulse Propellant	
LO2	782,084
RP-1	292,916
Residuals Gases And Liquids	5,910
Helium - Pressure System	11,790
Propellant - Pressure System	8,640
Glow	1,300,860

MARTIN MARIETTA
MANNED SPACE SYSTEMS

80914-02 Z

LRB PROPOSED ENGINE POSITIONS

- ALL GD CONFIGURATIONS (EXCEPT PRESSURE-FED) HAVE ENGINES POSITIONED AT 45-DEGREES TO THE MAJOR VEHICLE AXES ("X" PATTERN). THIS FACILITATES GIMBAL ACTUATORS ALONG THE PRIME PITCH AND YAW VEHICLE AXES, BUT REQUIRES A BRIDGE ACROSS THE BOOSTER FLAME HOLE TO SUPPORT THE NORTH HOLDDOWNS.

- ALL MMC CONFIGURATIONS HAVE ENGINES POSITIONED ALONG OR PARALLEL TO THE MAJOR VEHICLE AXES ("+" PATTERN). THIS FEATURE PERMITS THE USE OF THE SAME HAUNCH/HOLDDOWN LOCATIONS CURRENTLY IN USE ALONG THE SIDES OF THE FLAME HOLES, BUT MOVES OUTERMOST ENGINE CLOSER TO EDGE OF FLAME TRENCH - COMPLICATING FLAME DEFLECTOR DESIGN.

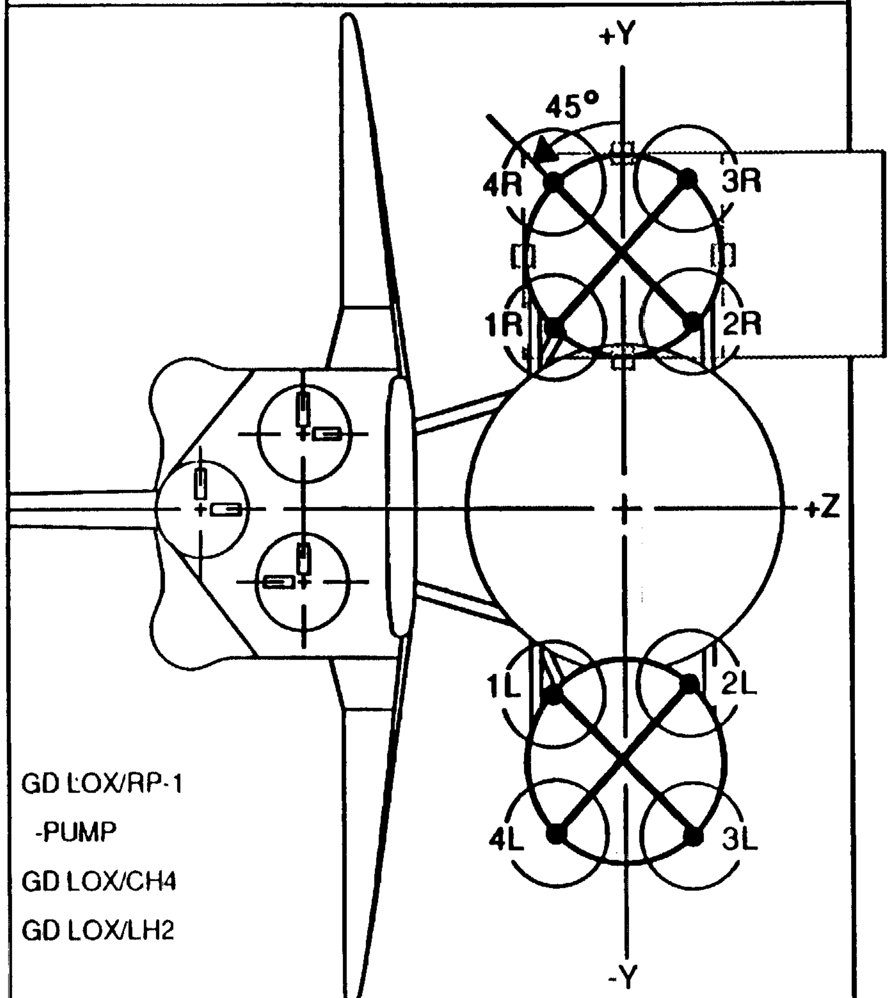
- GD PRESSURE-FED LOX/RP-1 HAS ENGINES POSITIONED IN THE "+" PATTERN (SAME AS MMC CONFIGURATION).

KSC ADVANCED PROJECTS & TECHNOLOGY OFFICE

LRB PROPOSED ENGINE PROPORTIONS (VIEWS LOOKING FORWARD)

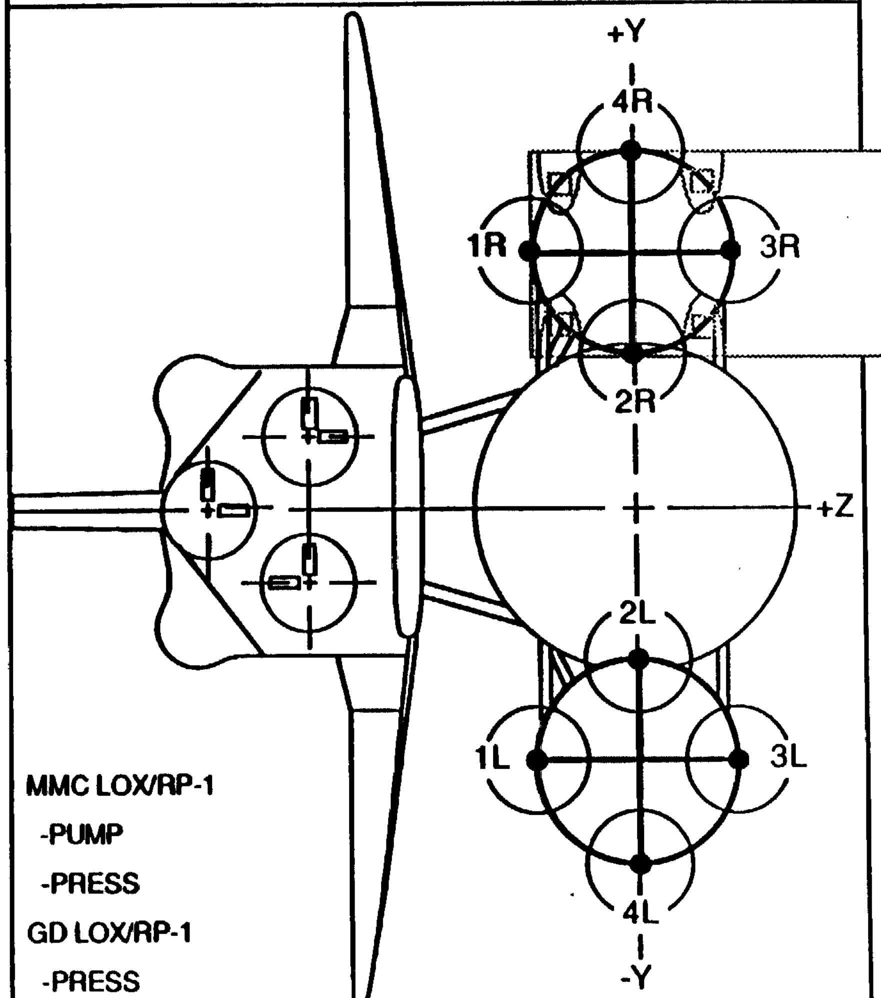
OCT 88

"X" PATTERN



GD LOX/RP-1
-PUMP
GD LOX/CH4
GD LOX/LH2

"+" PATTERN



MMC LOX/RP-1
-PUMP
-PRESS
GD LOX/RP-1
-PRESS

LRB CONFIGURATION UPDATE

GENERAL DYNAMICS

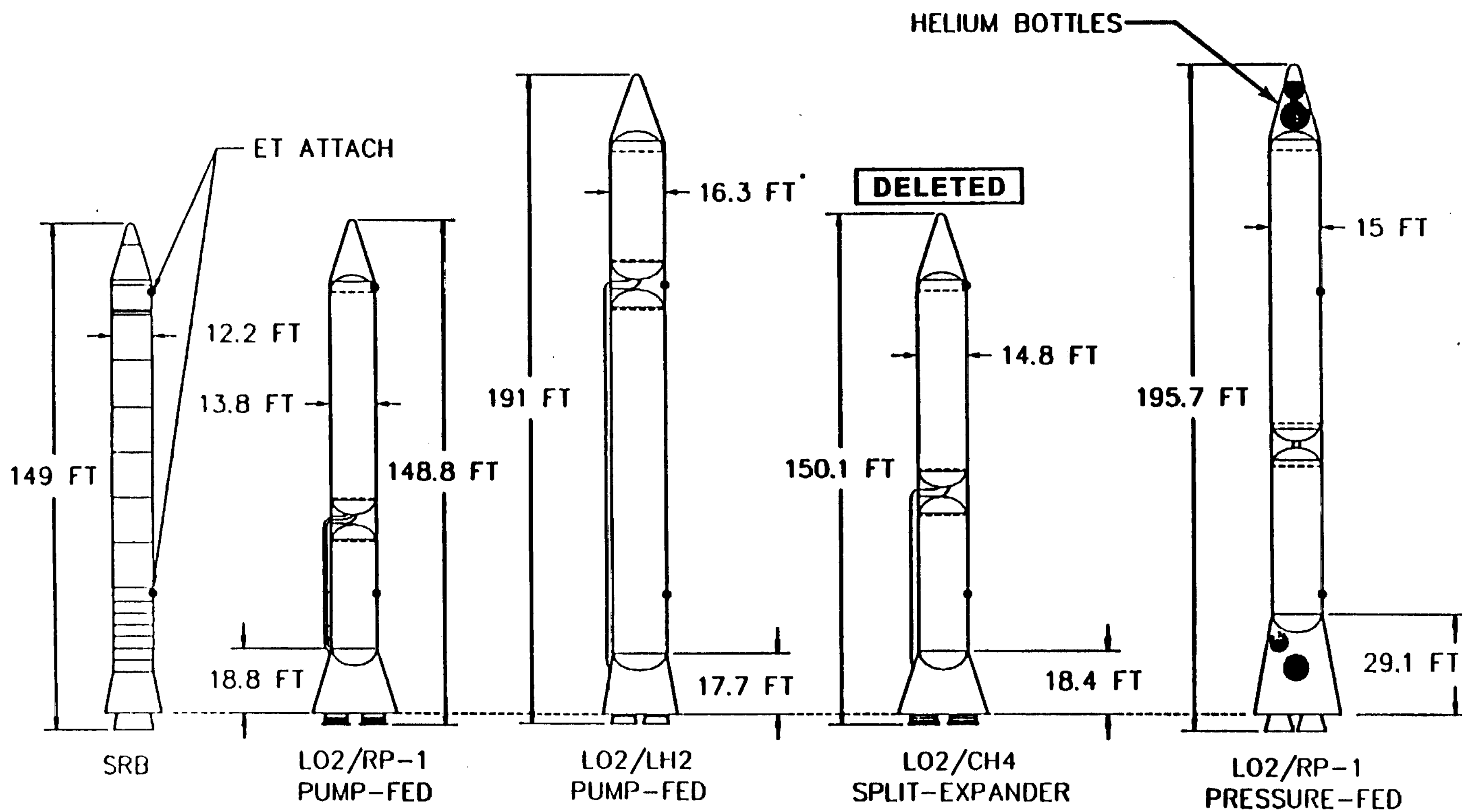
- PUMP-FED AND PRESSURE-FED LOX/RP1 CONFIGURATIONS REMAIN VIABLE OPTIONS. PUMP-FED SIZING IS CLOSEST TO SRB DIMENSIONS. PRESSURE-FED IS THE LARGEST AND USES CENTERED LOX FEED LINE THROUGH LOWER FUEL TANK. ET INTERFACE POINTS ARE NOTED ON THE CHART.

- STUDIES ASSOCIATED WITH LOX/CH_4 SPLIT EXPANDER HAVE SHOWN NO SIGNIFICANT ADVANTAGES AND THIS CONFIGURATION HAS BEEN DELETED. HOWEVER, AS SHOWN ON A SUBSEQUENT CHART THE ENGINE DESIGN IS BEING EVALUATED AS AN OPTION FOR THE LOX/LH_2 CONFIGURATION.

SELECTED LRB CONFIGURATIONS
AUGUST 1988

GENERAL DYNAMICS
Space Systems Division

LRB



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LO_2/LH_2 PUMP FED LRB (LENGTH VS DIAMETER)

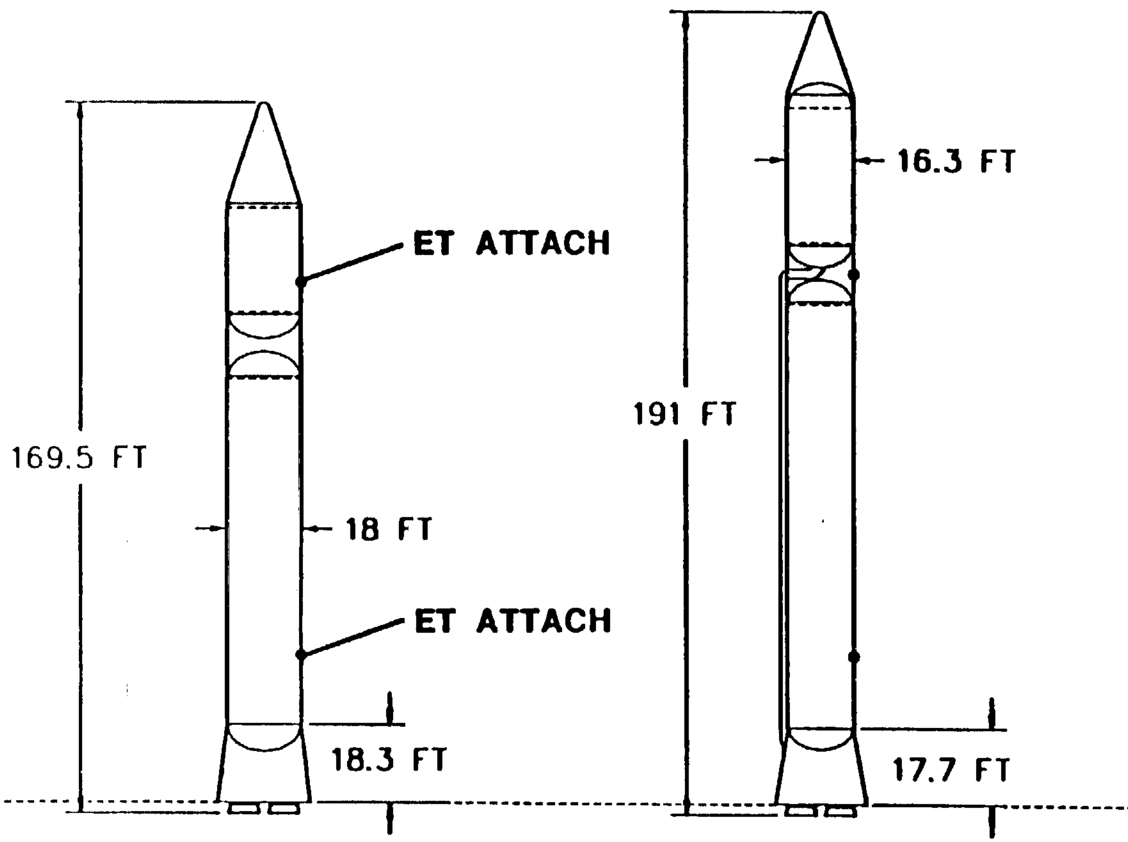
- THE LO_2/LH_2 CONFIGURATION HAS BEEN RETAINED AND IS THE TARGET OF SOME RESIZING STUDIES. SHORTENED LENGTH ALLOWS CLEARANCE FOR ET GOX VENT ARM AT PAD WHILE RESULTING DIAMETER GROWS TO NEAR 18 FT.

- THIS ALSO RESULTS IN FORWARD ET ATTACH POINT IN A MID-TANK AREA (NOT CONSIDERED A GOOD POINT FOR TRANSFERRING 3 M POUNDS OF THRUST).

LO2/LH2 PUMP FED LRB LENGTH VS DIAMETER

GENERAL DYNAMICS
Space Systems Division

LRB



FATBIRD
STRUCTURE WEIGHT=52,886
DRY WEIGHT=103,339
LIFT OFF WEIGHT=763,367

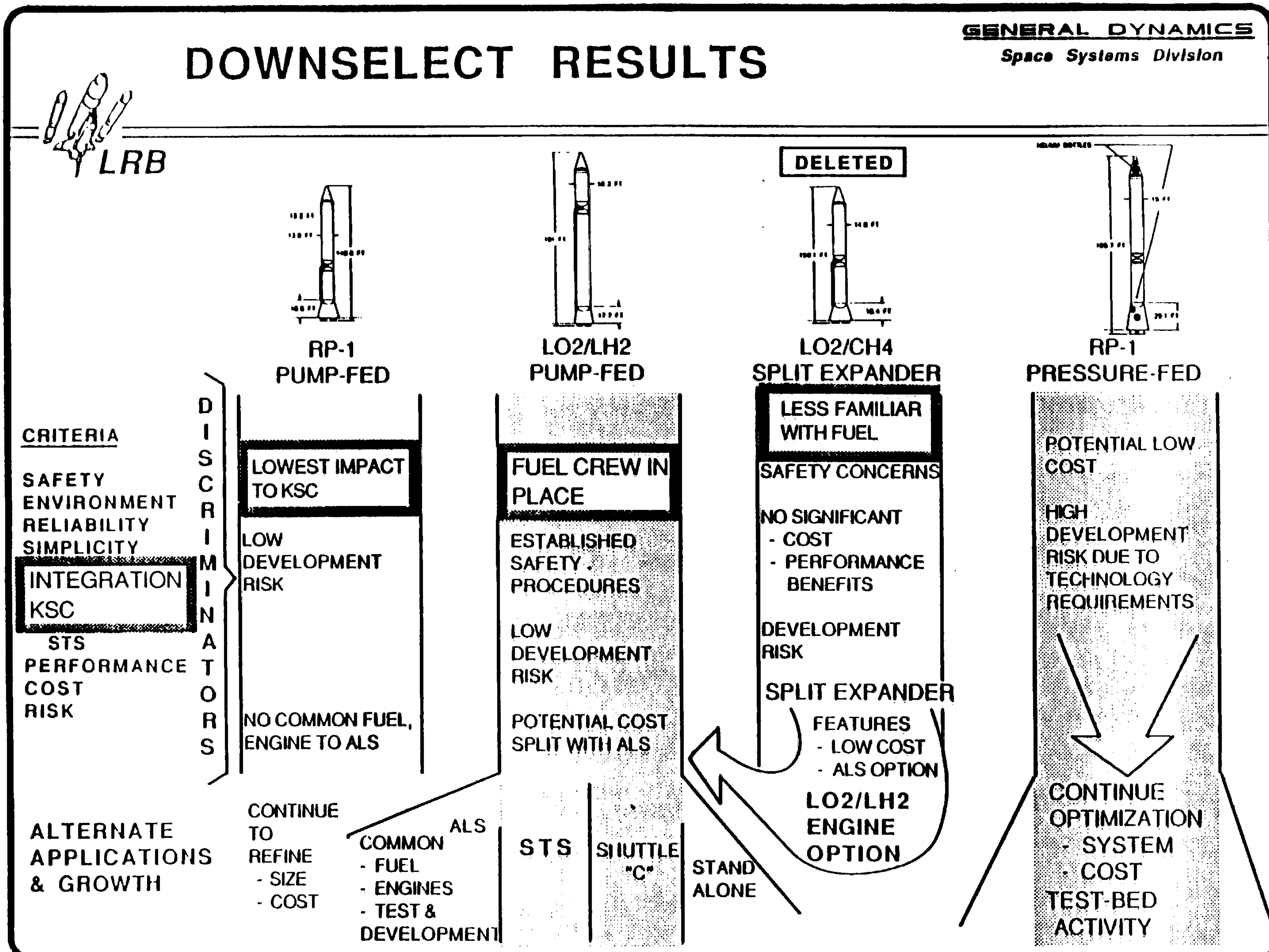
LO2/LH2
STRUCTURE WEIGHT=58,237
DRY WEIGHT=108,822
LIFT OFF WEIGHT=751,037

LRB CONFIGURATION UPDATE

GENERAL DYNAMICS

- GD's DOWNSELECT RESULTS INDICATE THE ATTENTION GIVEN TO KSC LAUNCH SITE INTEGRATION AS A PROMINENT CRITERIA (NOTE THE HIGHLIGHTED AREAS).

- WE THINK THEY ARE LISTENING - NOW IF WE CAN GET DOWN TO THE BEST <u>TWO</u> CONFIGURATIONS . . . .



GENERAL DYNAMICS
Space Systems Division
DOWNSELECT RESULTS
LRB
DELETED
RP-1
PUMP-FED
LO2/LH2
PUMP-FED
LO2/CH4
SPLIT EXPANDER
RP-1
PRESSURE-FED
CRITERIA
SAFETY
ENVIRONMENT
RELIABILITY
SIMPLICITY
INTEGRATION
KSC
STS
PERFORMANCE
COST
RISK
DISCRIMINATORS
LOWEST IMPACT TO KSC
LOW DEVELOPMENT RISK
NO COMMON FUEL, ENGINE TO ALS
FUEL CREW IN PLACE
ESTABLISHED SAFETY PROCEDURES
LOW DEVELOPMENT RISK
POTENTIAL COST SPLIT WITH ALS
LESS FAMILIAR WITH FUEL
SAFETY CONCERNS
NO SIGNIFICANT
- COST
- PERFORMANCE BENEFITS
DEVELOPMENT RISK
SPLIT EXPANDER
FEATURES
- LOW COST
- ALS OPTION
LO2/LH2 ENGINE OPTION
POTENTIAL LOW COST
HIGH DEVELOPMENT RISK DUE TO TECHNOLOGY REQUIREMENTS
ALTERNATE APPLICATIONS & GROWTH
CONTINUE TO REFINE
- SIZE
- COST
ALS
COMMON
- FUEL
- ENGINES
- TEST & DEVELOPMENT
STS
SHUTTLE "C"
STAND ALONE
CONTINUE OPTIMIZATION
- SYSTEM
- COST
TEST-BED ACTIVITY

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LRB REQUIREMENTS SUMMARY (PER GDSS)

ITEM	TOTAL	NUMBER WITH GROUND SYSTEMS IMPLICATIONS
A. GUIDELINES GOALS, ASSUMPTIONS	12	11
B. LEVEL I REQUIREMENTS (SPACE TRANSPORTATION SYSTEM)	8	7
C. LEVEL II REQUIREMENTS (SPACE SHUTTLE VEHICLE)	8	4
D. LEVEL III REQUIREMENTS (LIQUID ROCKET BOOSTER)	11	9
E. LEVEL IV REQUIREMENTS (AVIONICS / FLT CONTROLS / SEPARATION SYSTEMS)	9	2
TOTALS	48	33

C-6

LRB CONFIGURATION UPDATE

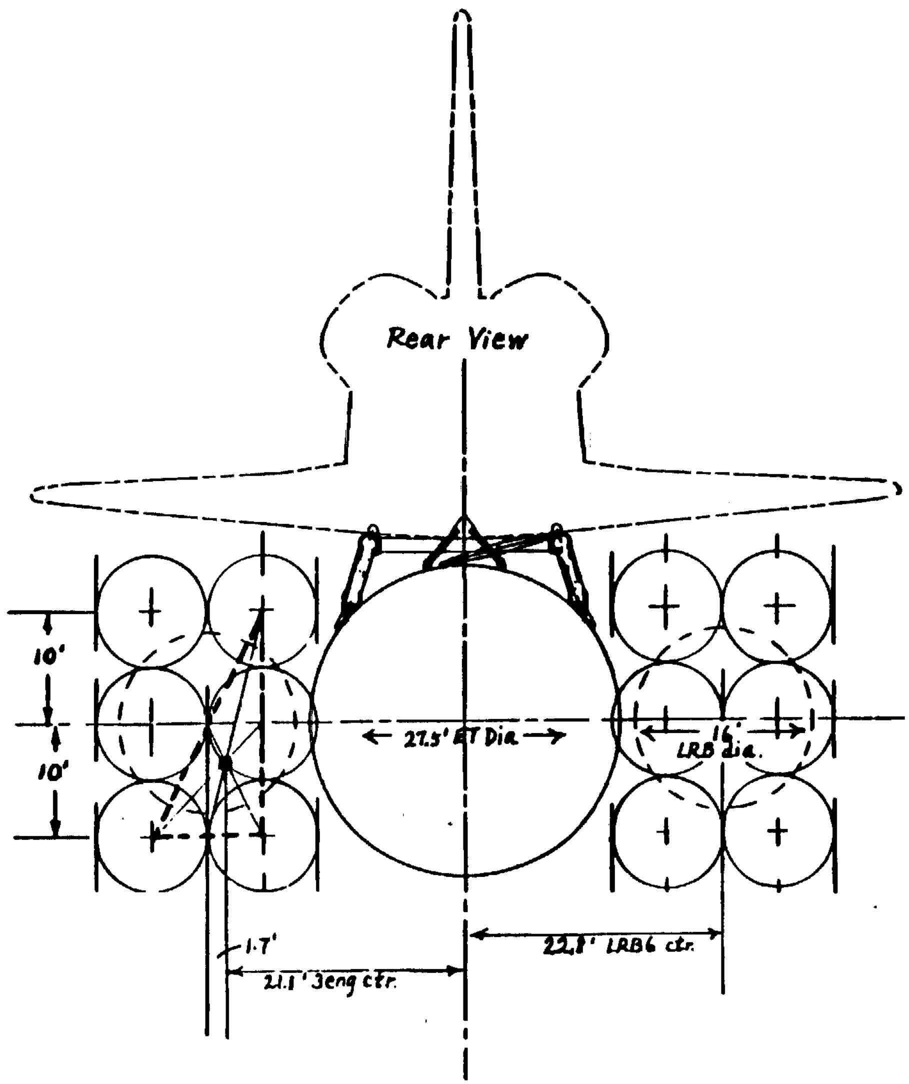
JSC

- RENEGADE LRB OPTIONS SUCH AS THIS SIX-ENGINED "LAB RAT" CONFIGURATION STILL STRUGGLE FOR RESPECTABILITY AT OUR PERIODIC TECHNICAL WORKING GROUP MEETINGS.
- HIDDEN ADVANTAGES OF THIS APPROACH INCLUDE FIXED ENGINES (NO GIMBALING) AND THRUST VECTOR CONTROL VIA DIFFERENTIAL THROTTLING. ADDITIONAL ENGINE-OUT CAPABILITY IS ALSO ACHIEVED.
- IDEAS SUCH AS THESE WILL CARRY OVER INTO THE PHASE B ACTIVITIES - SO WE MUST STAY FLEXIBLE.

LIQUID ROCKET BOOSTER INTEGRATION SECOND PROGRESS REVIEW

OCT 1988

SIX-ENGINE PRESS-FED LRB "LAB RAT"



LRB PROCESSING SUMMARY

THE LRB PROCESSING SCENARIO BEGINS AT KSC WITH BARGE DELIVERY, AND HORIZONAL TRANSPORTER TOW TO THE NEW LRB PROCESSING FACILITY. HERE ALL STANDALONE BOOSTER CHECKOUT AND TESTING IS CONDUCTED. THE ADJACENT ET HORIZONAL PROCESSING FACILITY RELOCATES THE ET CHECKOUT AND STORAGE ACTIVITY SO THAT HB4 CAN BE USED.

THE CONVERSION OF VAB/HB4 TO A FULL INTEGRATION CELL PERMITS LRB TRANSITION WITHOUT IMPACT TO ON-GOING SHUTTLE LAUNCHES. A NEW MLP CUSTOM-BUILT FOR LRB WILL BE CONSTRUCTED TO SUPPORT THE LRB IOC, AND A SECOND NEW MLP IS NOW SCHEDULED TO SUPPORT THE LRB TRANSITION LAUNCH RATE BUILD-UP. THIS APPROACH REPLACES THE EARLIER PLANNED MODIFICATION OF EXISTING MLP's.

THE LAUNCH CONTROL CENTER FIRING ROOMS WILL BE MODIFIED TO SUPPORT ANY NEW CONSOLES AND GROUND SOFTWARE REQUIRED FOR LRB PROCESSING AND LAUNCH OPERATIONS.

CHANGES SINCE LAST REVIEW:

- SECOND NEW MLP DUE TO: 1) DIFFICULTY OF MOD AND 2) IMPACT TO SRB LAUNCHES
- NEW MORE EXTENSIVE PAD MODS:
  1) DEFLECTOR REDESIGN IN FLAME TRENCH
  2) SIDE DEFLECTOR (PROXIMITY REQUIREMENTS)
  3) <u>POSSIBLE</u> FLAME TRENCH MODS

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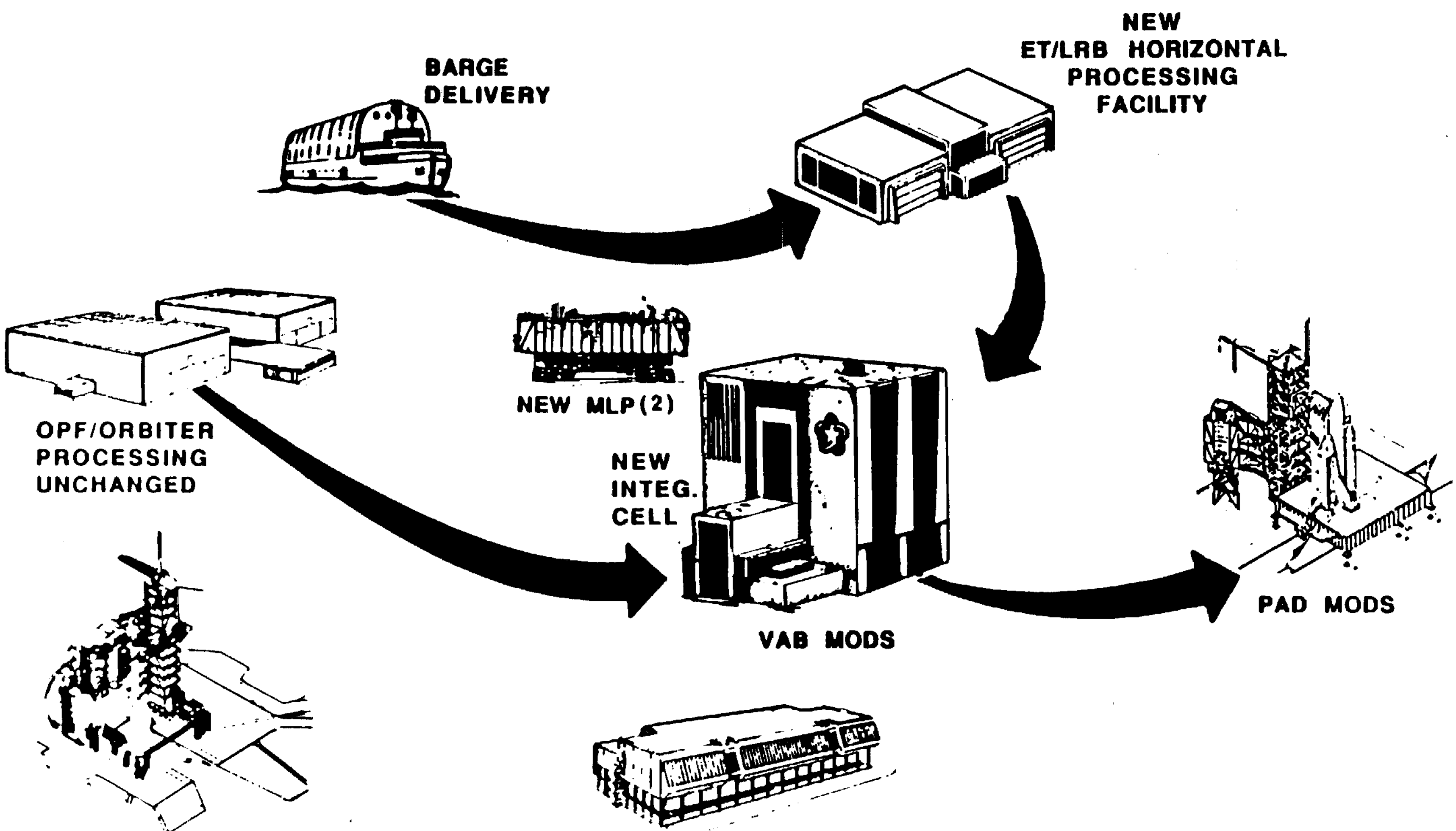
LIQUID ROCKET BOOSTER INTEGRATION SECOND PROGRESS REVIEW

OCT 1988

TASK 3 - PRELIMINARY LRB SCENARIOS

LRB PROCESSING SUMMARY



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LRB INTEGRATION - A PHASED APPROACH

- LAUNCH SITE ACTIVATION BEGINS IN FY 91 TO SUPPORT INITIAL LRB LAUNCH CAPABILITY IN 1995. FIRST LINE NEW FACILITIES, REQUIRED FACILITY MODS AND NEW GSE/LSE ARE DESIGNED, CONSTRUCTED AND VALIDATED DURING THIS INITIAL FIVE YEAR PERIOD. THESE ACTIVATION SCHEDULES ARE LAID OUT IN AN ARTEMIS MODEL AND PLANNED ON A NON-INTERFERENCE BASIS.

- THE TRANSITION PHASE BEGINS WITH 3 LAUNCHES OF LRB IN 1996 AND BUILDS TO THE FULL 14 ANNUAL LAUNCH MANIFEST BY THE YEAR 2000. DURING THIS PERIOD SRB-BOOSTED LAUNCHES ARE PHASED DOWN BY SIMILAR INCREMENTS. AS YOU CAN SEE, ADDITIONAL FACILITY (AND GSE) ACTIVATIONS ARE SCHEDULED OVER THIS TRANSITION - MAJOR ONES ARE NOTED HERE.

- TOTAL LIFE CYCLE EVALUATIONS ARE DIMENSIONED OVER AN APPROXIMATE 10-YEAR LAUNCH PERIOD. THE LAST 5 YEARS ARE AT THE FULL 14/15 FLIGHTS PER YEAR RATE. A TOTAL LRB LIFE OF 122 MISSIONS IS CURRENTLY PROJECTED.

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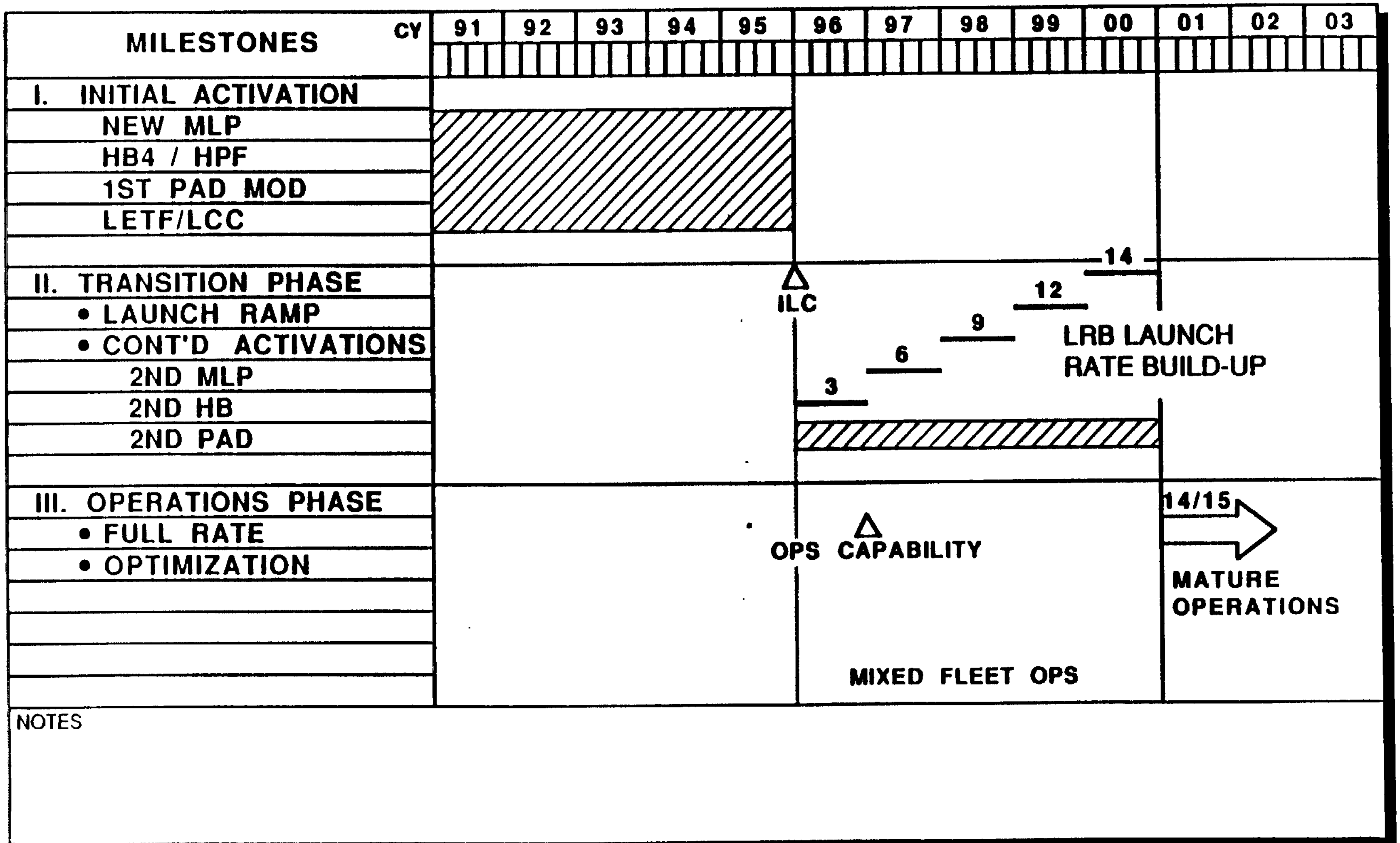
LIQUID ROCKET BOOSTER INTEGRATION SECOND PROGRESS REVIEW

OCT 1988

PHASED APPROACH



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GENERIC LRB PROCESS FLOW

- AFTER A DETAILED ANALYSIS AND UPDATE OF THE 130-TASK LRB PROCESSING FLOW, IT WAS FOUND THAT THE PLANNED MLP MATE AND CLOSEOUTS (PRIOR TO ET MATE) COULD BE REDUCED FROM 6 DAYS TO 4 DAYS. THIS RESULTS IN A TOTAL LRB FLOW OF 51 DAYS FROM RECEIPT OF HARDWARE TO LAUNCH. THIS SUMMARY OF THE 130-TASK FLOW ILLUSTRATES MAJOR FUNCTIONAL FLOW TIME IN WORK DAYS.

- OTHER REFINEMENTS ADDED TO THIS MODEL INCLUDE UPDATED ENGINE PROCESSING TASKS AND MANPOWER MODEL UPDATES TO ALL LRB TASK AREAS. THE PROCESSING MODEL IS NETWORKED AND MAN-LOADED IN ARTEMIS AND IS CURRENTLY IN USE FOR EVALUATIONS OF BOTH MANPOWER AND GSE REQUIREMENTS FOR EACH STATION SET.

- MAJOR LRB ACTIVITIES ARE HIGHLIGHTED HERE IN THIS TOP LEVEL SUMMARY CHART.

LIQUID ROCKET BOOSTER INTEGRATION SECOND PROGRESS REVIEW

OCT 1988

GENERIC LRB PROCESS FLOW

▲ LRB BARGE ON DOCK KSC

11 — LRB STANDALONE CHECKOUT (5/3)

- OFFLOAD/TRANS TO HPF
- REC/INSP
- SYS FUNCT CHECKOUTS
- ENGINE/PROP SYS LEAK & FUNCTIONAL

▲ LRB MOVE TO VAB

4 — MLP MATE & CLOSEOUTS (7/3)

LRB FLOW = 51 DAYS

▲ ET MATE

11 — ET/LRB CLOSEOUTS (7/3)

▲ 5 — ORB MATE/INTEG SYS TEST (7/3)

SSV PREPS/TRANSFER TO PAD ▲

LAUNCH (6/3)

20

- SSV STD OPS
- PAYLOAD OPS
- CDDT
- LRB ENG SYS READINESS
- LRB FUEL (RP) TANKING
- ORB HYPER LOAD/CLOSEOUT
- LAUNCH COUNTDOWN (INCLUDING CRYO LOAD)

STS BASELINE MODEL

- o MULTI-FLOW PROCESSING TIMELINES ARE COMPLETE FOR STS LAUNCHES 1991 THRU 2006 (ARTEMIS MODEL)
- o THIS SCHEDULE REPRESENTS THE STS TRANSITION FROM NEAR TERM MANIFEST (MAR 88) TO LONG RANGE LAUNCH RATE OF 14/15 PER YEAR
- o FACILITY UTILIZATION DIAGRAMS PRESENT WINDOWS FOR SCHEDULING LRB FACILITY MODS/ACTIVATION
- o PLANNING LAYOUTS FOR ACTIVATION/TRANSITION/OPERATIONS PHASES CAN NOW BE PREPARED/UPDATED
- o MINIMUM IMPACTS TO ON-GOING LAUNCH OPERATIONS CAN BE ASSURED

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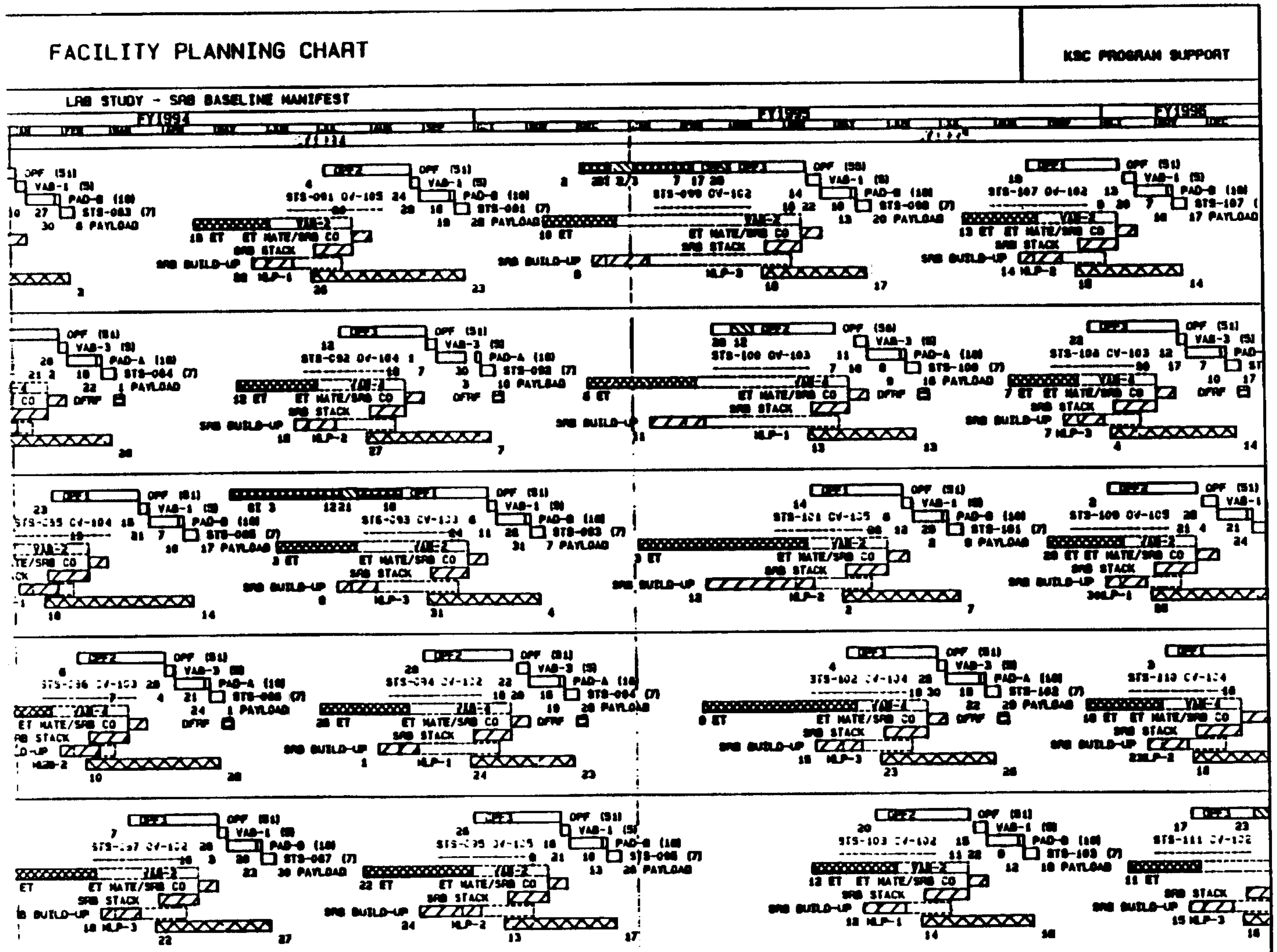
LIQUID ROCKET BOOSTER INTEGRATION SECOND PROGRESS REVIEW

OCT 1988

ARTEMIS STS BASELINE MODEL



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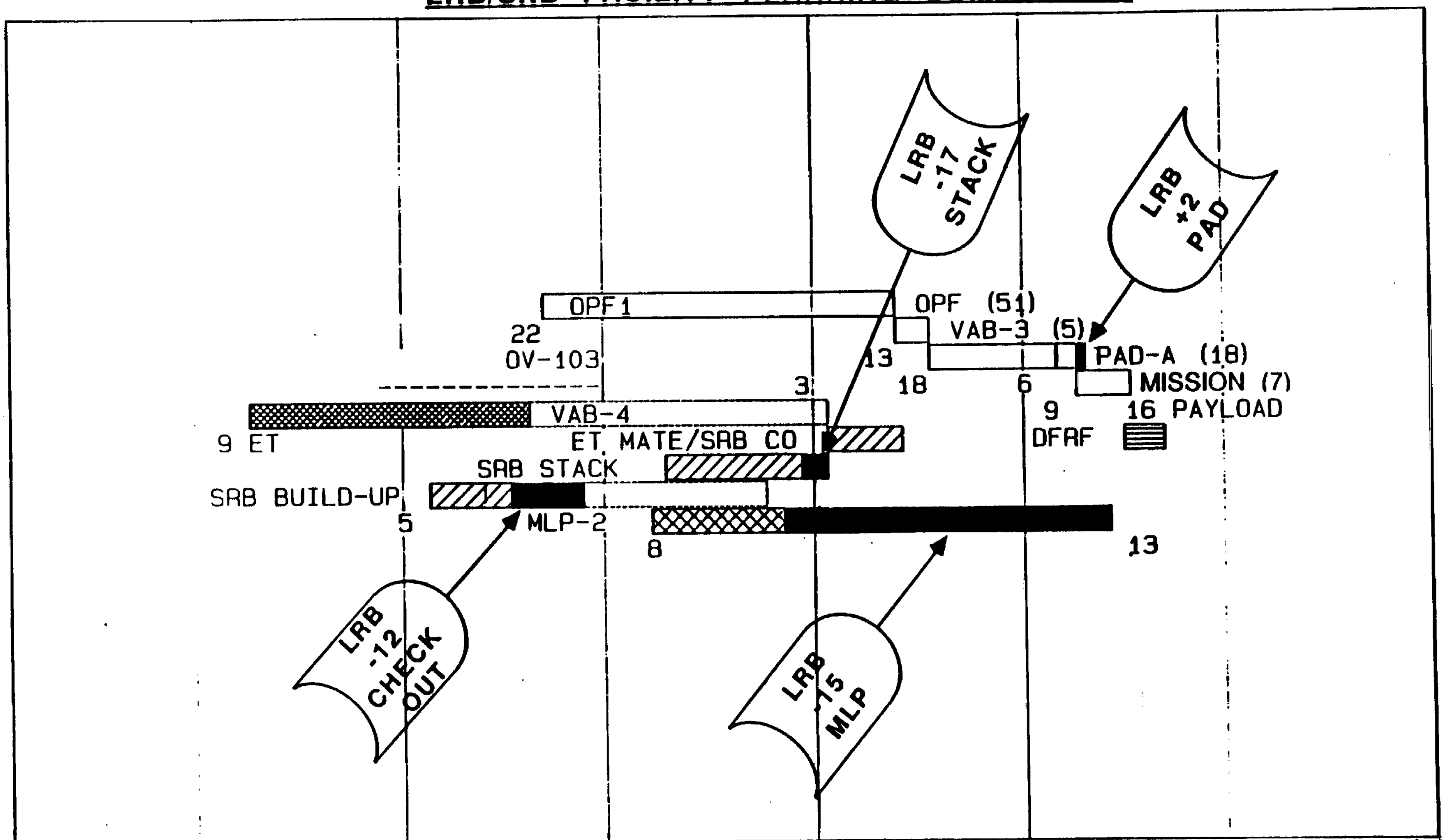
LRB/SRB FACILITY PLANNING COMPARISON

- GRAPHICALLY NOTED HERE ARE THE FLOW TIME DIFFERENCES FOR LRB (SHOWN SOLID BLACK) ON THE BACKDROP OF PLANNED SRB FLOW PROCESSING TIMELINES IN THE MID-TO-LATE 90's.

- ALL IN-LINE GROUND PROCESSING TO SUPPORT AN EXAMPLE FLOW IS PRESENTED. NOTE MAJOR FACILITIES AND ELEMENTS. THE LRB CHANGES ARE SHOWN IN THE BOXES FOR THE FOUR AFFECTED FACILITIES.

- THE ARTEMIS MULTIFLOW PROCESSING MODEL CONTAINS 224 MISSIONS OF THIS DETAIL OVER THE PERIOD FY 91 THRU FY 06. INSERTION OF THE 122 LRB LIFE CYCLE MISSION PROFILE INTO THIS MODEL WILL FACILITATE EFFECTIVE PLANNING FOR KSC INTEGRATION.

LRB/SRB FACILITY PLANNING COMPARISON



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Space Operations Company

SRB/LRB FLOW COMPARISON

- SUMMARIZED HERE ARE THE PROJECTED IMPROVEMENTS IN FLOW TIME FOR LRB VERSUS THE "PLANNED" SRB PROCESSING TIMES FORECAST FOR THE LATE 90's.

- THESE IMPROVEMENTS REPRESENT A SIGNIFICANT REDUCTION IN DEMAND ON LAUNCH SITE RESOURCES REQUIRED TO SUPPORT A 14 TO 15 ANNUAL LAUNCH RATE - AND THEY PROVIDE THE FLEXIBILITY TO ACCOMMODATE ALTERNATE SHUTTLE "C" OR ALS LAUNCH CAPABILITIES.

LIQUID ROCKET BOOSTER INTEGRATION SECOND PROGRESS REVIEW

OCT 1988

SRB/LRB FLOW COMPARISON

	WORK DAYS		% REDUCTION
	SRB	LRB	
VAB HB (INTEG CELL)	21	4	81%
MLP USE PER FLOW	55	40	27%
INTEG CRITICAL PATH (BOOSTER STACK TO ORB MATE)	32	15	53%
PAD FLOW	18	20	-11%
BOOSTER FLOW (PRE-LAUNCH)	78	51	35%

OVERVIEW OF LAUNCH SITE PLAN

- THE OVERALL LAUNCH SITE PLAN SPANS A PERIOD OF 15 + YEARS AND CONTAINS THE MAJOR PHASES SHOWN HERE.

- OUR FINAL REPORT WILL DOCUMENT THESE PHASES IN THE FORM OF STUDY PRODUCTS SUCH AS:

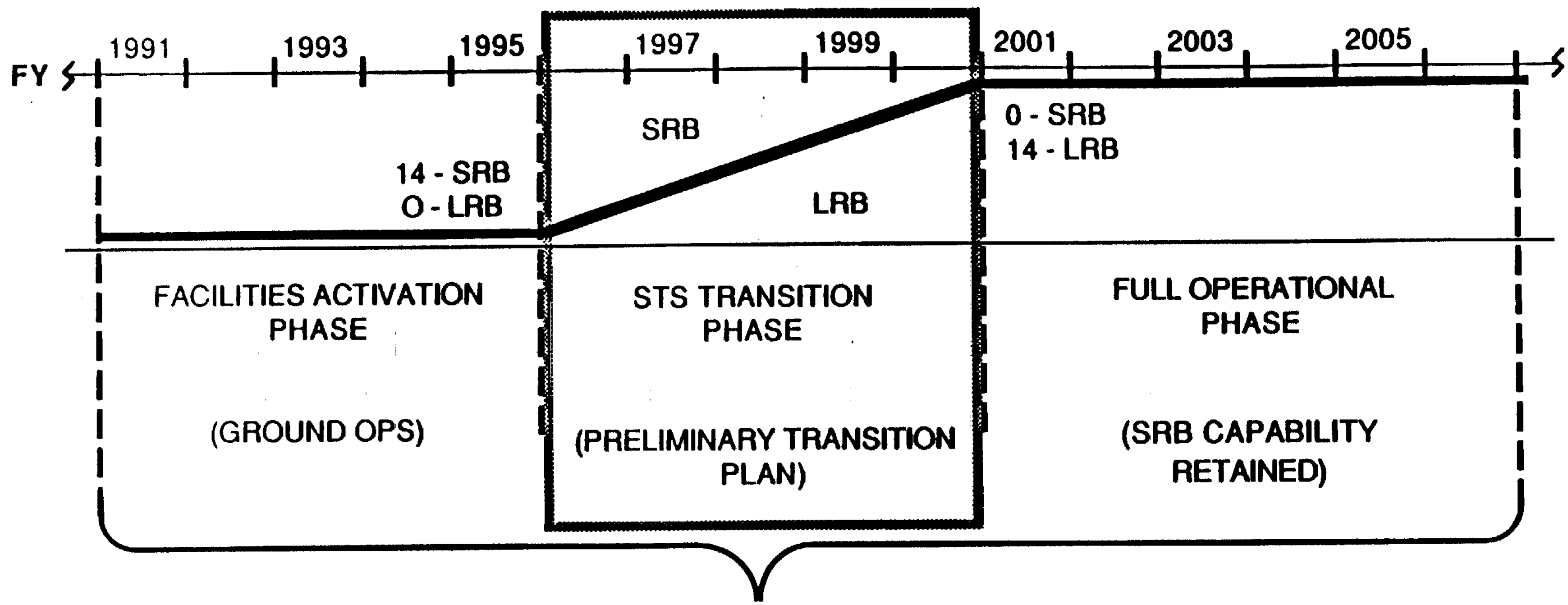
  - GROUND OPERATIONS PLAN - COVERS ALL ASPECTS OF LRB FACILITY ACTIVATIONS/MODS AND GSE/LSE DESIGN/INSTALLATION FOR ALL STATION SETS.

  - PRELIMINARY TRANSITION PLAN - COVERS ALL ASPECTS OF THE FIVE-YEAR CHANGE FROM SRB TO LRB OPERATIONS.

KSC ADVANCED PROJECTS & TECHNOLOGY OFFICE

OVERVIEW OF LAUNCH SITE PLAN

OCT 88



LRB
LAUNCH SITE PLAN*

* TIME LINE BASED ON ACCOMPLISHING A MINIMUM OF 122 LRB BOOSTER MISSIONS IN THE PROGRAM LIFE CYCLE

A-17.1

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LRB PRELIMINARY TRANSITION PLAN

o IN ORDER TO PROJECT NEW FACILITY "NEED" DATES AND TO OPTIMIZE EXISTING FACILITY "DOWN-TIME" FOR CONVERSION IT IS NECESSARY TO:

- ASSURE ACCOMPLISHMENT OF A PRE-ESTABLISHED LAUNCH RATE (A MINIMUM OF 14 LAUNCHES PER YEAR BETWEEN 1996 & 2000.
- PROVIDE FOR PARALLEL PROCESSING OF BOTH LRB AND SRB CONFIGURATIONS (A DUAL CAPABILITY IS TO BE RETAINED TRHOUGHOUT THE TRANSITION PERIOD)
- ANTICIPATE LAUNCH PROCESSING MANPOWER REQUIREMENTS (JOB ASSIGNMENT, NUMBERS, SKILLS AND LOCATION)
- CALCULATE THE BUDGETARY EXPENDITURES EXPECTED DURING THIS PERIOD (SOURCE OF FUNDS, YEARLY ACCOUNTING, RELATION TO TOTAL PROGRAM COSTS)
- ARRANGE THE AVAILABILITY OF DOCUMENTATION TO SUPPORT BOTH KSC FLIGHT HARDWARE PROCESSING AND GSE/LSE READINESS.

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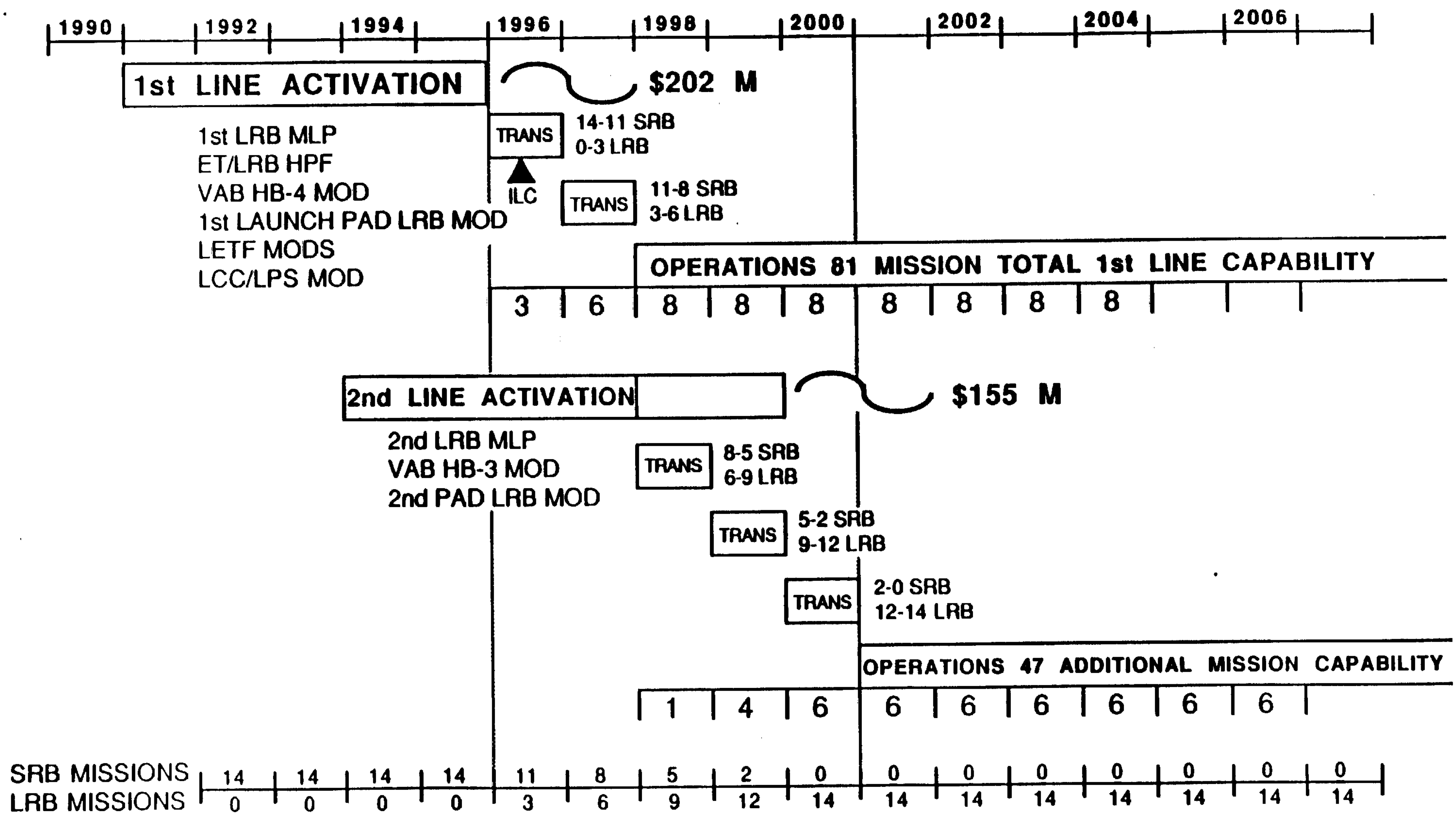
LIQUID ROCKET BOOSTER INTEGRATION SECOND PROGRESS REVIEW

OCT 88

KSC SRB TO LRB TRANSITION PLAN



TOTAL LRB MISSIONS THRU 2006=128

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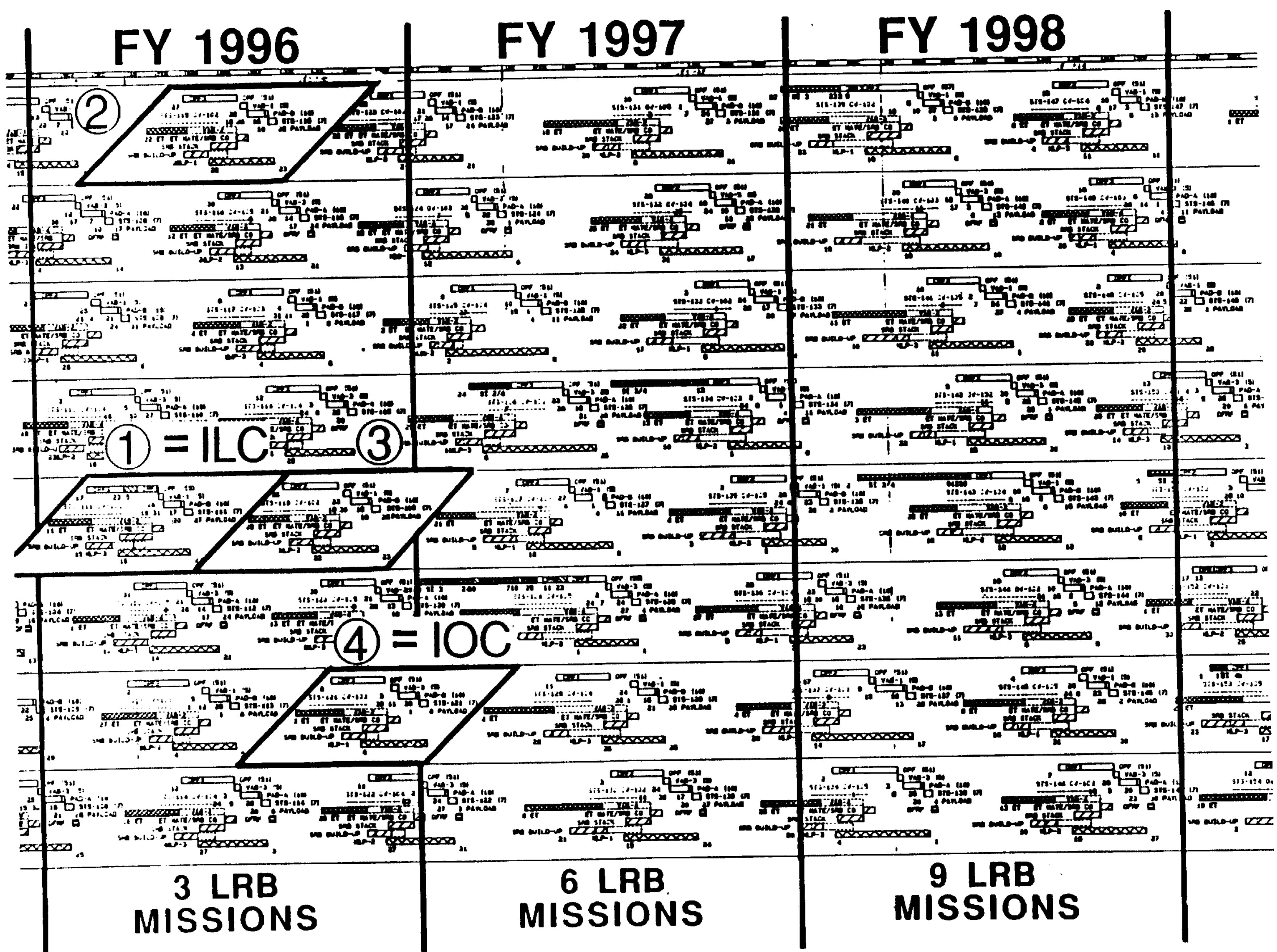
LRB PRELIMINARY TRANSITION PLAN

PROGRESS MADE DURING THE LAST QUARTER

- DIVISION OF PROGRAM INTO
  - 1ST AND 2ND LINES OF FACILITY ACTIVATION
  - 3 PHASE APPROACH: ACTIVATION, TRANSITION AND OPERATIONS
- CORRELATION OF FACILITY ACTIVATION AND CONVERSION SCHEDULES WITH INCREMENTAL TRANSITION LAUNCH GOALS
- SELECTION OF THE FIRST LRB MISSION (STS 111 - FEB 20, 1996) AND PROVIDE FOR A LENGTHY FIRST FLOW.
  - BASED ON PROJECTED 1991 PROGRAM START
  - LATEST FLIGHT HARDWARE DELIVERY AND FACILITY COMPLETION DATES
- CHARTING OF THE FIRST LRB PROCESSING FLOW AND THE NEXT THREE LEADING UP TO INITIAL OPERATIONAL CAPABILITY (4TH LAUNCH).

LRB PRELIMINARY TRANSITION PLAN

OCT 88



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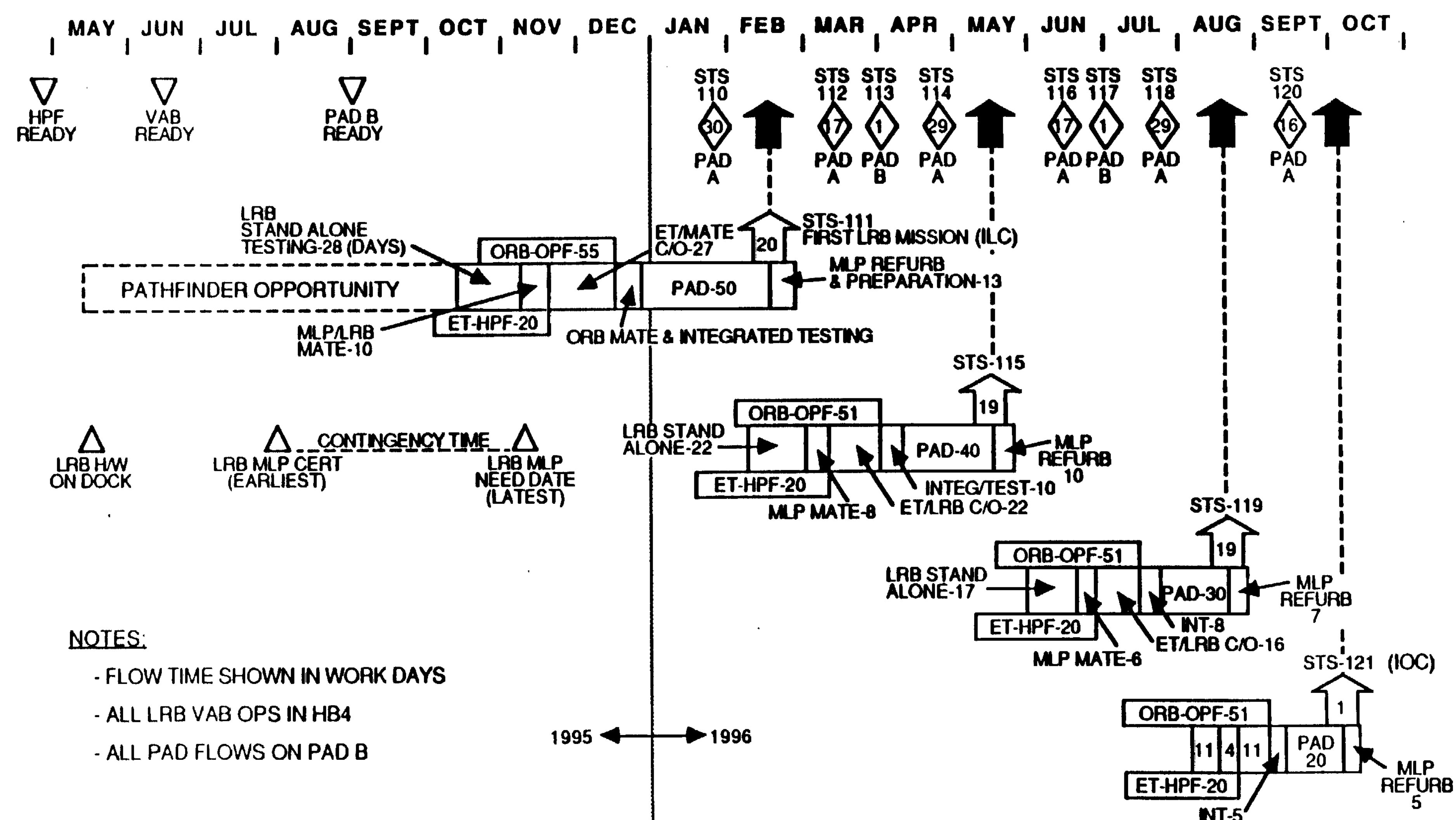
LRB PRELIMINARY TRANSITION PLAN

FLOW CHART OF THE FIRST FOUR LRB MISSION PROCESSING CYCLES LEADING TO IOC

- LENGTH OF PROCESSING TIME EXPECTED FOR AN OPERATIONAL MISSION MULTIPLIED BY A FACTOR OF 2.5 FOR FIRST FLOW THEN 2.0 AND 1.5 RESPECTIVELY FOR SECOND AND THIRD FLOWS
- FOURTH FLOW IS EXPECTED TO DEMONSTRATE OPERATIONAL PROCESSING TIMELINES

LRB PROCESSING/LAUNCH TRANSITION TO I.O.C.

OCT 1988



NOTES:

- FLOW TIME SHOWN IN WORK DAYS
- ALL LRB VAB OPS IN HB4
- ALL PAD FLOWS ON PAD B

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LRB PRELIMINARY TRANSITION PLAN

- "MAJOR ISSUES" REMAINING TO BE ACCOMPLISHED
  - COMPLETE INTEGRATION OF LRB GENERIC FLOWS AND FACILITY ACTIVATIONS INTO THE MULTI-MISSION MODEL
  - IDENTIFY AND DOCUMENT ALL DESIGN AND SCHEDULE IMPACTS
  - COMPLETE ESTIMATES OF KSC TRANSITION REQUIREMENTS FOR LRB AND THE ASSOCIATED MANPOWER AND SKILLS NEEDED
  - SCOPE CHANGES REQUIRED IN GROUND SOFTWARE AND LAUNCH CONTROL CENTER FOR LRB
  - DEFINE AND DOCUMENT ALL "DELTAS" BETWEEN SELECTED DESIGN CONFIGURATIONS AND PROPOSED VENDOR APPROACHES

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LIQUID ROCKET BOOSTER INTEGRATION
SECOND PROGRESS REVIEW

OCT 1988

2. TECHNICAL WORKING GROUP ACTIVITIES

- LRB ASCENT PERFORMANCE / ABORT ANALYSIS
- TOWER CLEARANCE STUDIES
- BASELINE VEHICLE EXCURSIONS AT PAD
- COORDINATION OF PHASE A COST ESTIMATES

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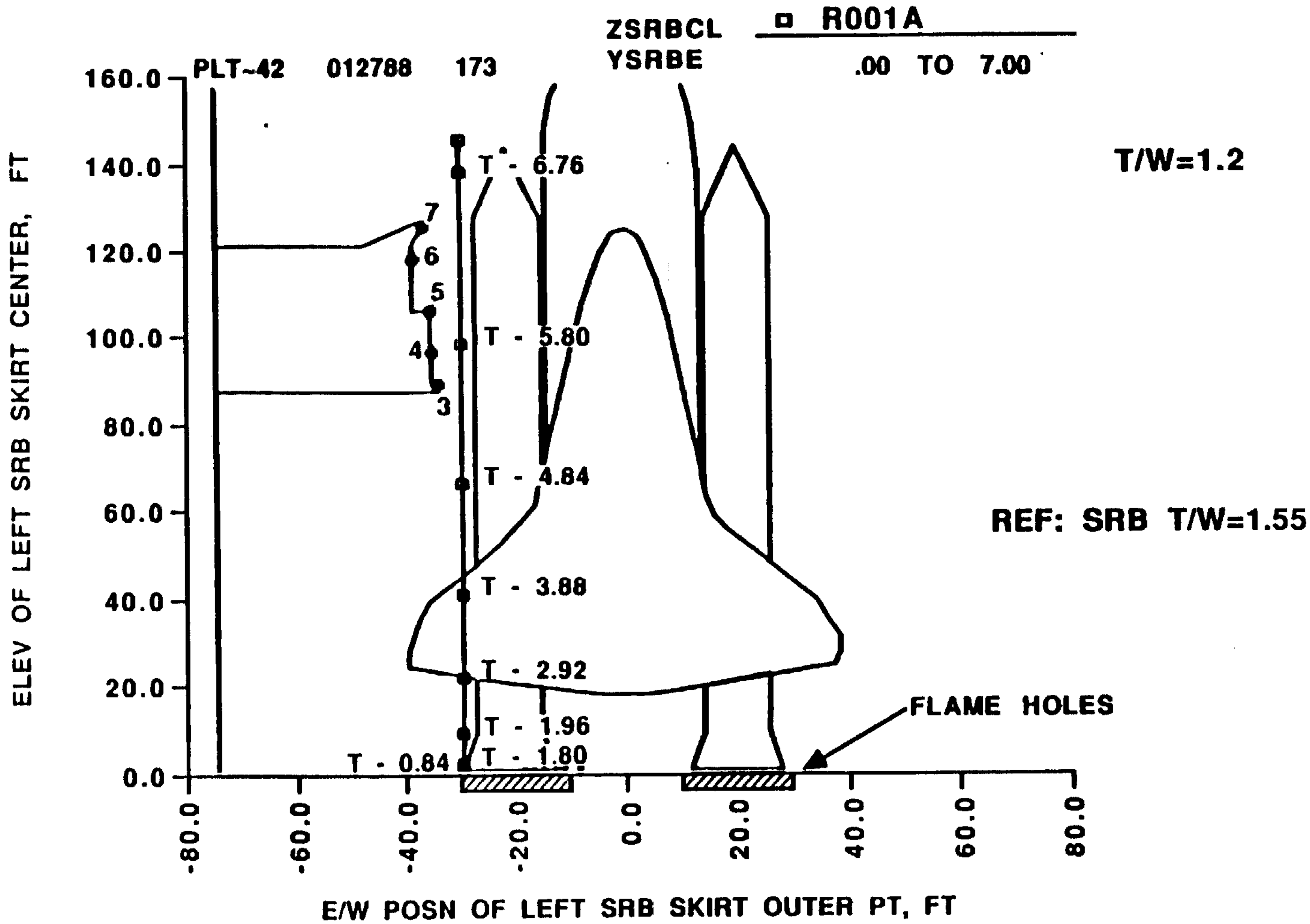
LRB/STS INTEGRATION / ANALYSIS BY LESC/JSC

- STS/LRB ASCENT FLIGHT DESIGN
  - GD AND MMC CONFIGURATIONS (5)
  - ASCENT PERFORMANCE
  - INTACT ABORT PERFORMANCE
- CONTINGENCY ABORT ASSESSMENT
- LRB CONTROLLABILITY ANALYSIS
- LRB FMEA/CIL ANALYSIS
- JSC MISSION OPERATION DIRECTORATE (MOD) IMPACTS

LRB/STS TOWER CLEARANCE STUDIES

- DRIFT CURVES/ENGINE OUT CONDITIONS
- LRB ENGINE OUT/SSME ENGINE OUT (NO. 2)
- THRUST/WEIGHT DESIGN GOALS (1.6 OR 1.2)
- PRE-LAUNCH VEHICLE EXCURSIONS AT PAD (LRB VS SRB)

LRB TOWER CLEARANCE ANALYSIS R001A



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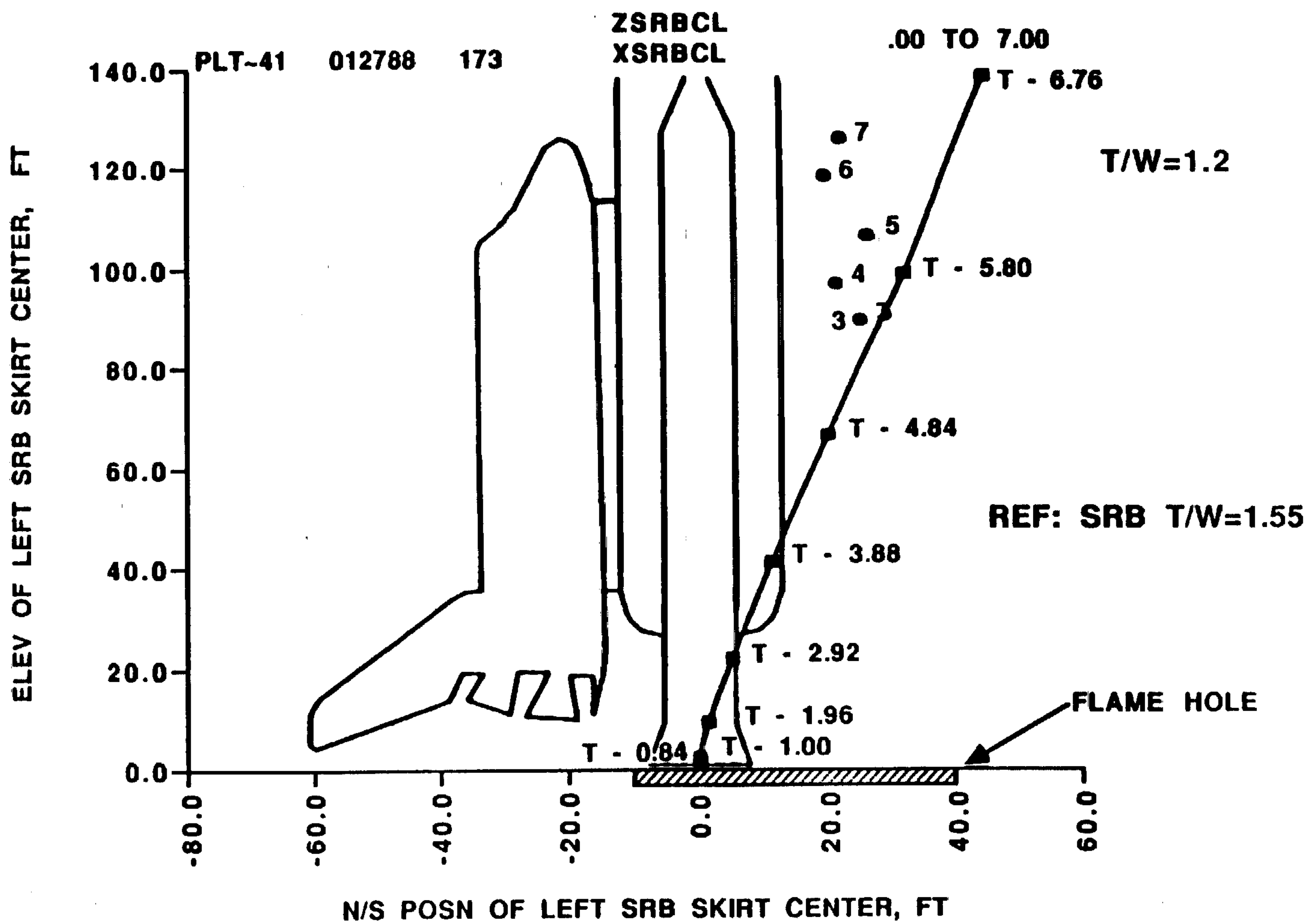
LRB TOWER CLEARANCE ANALYSIS R001A



BASELINE VEHICLE EXCURSIONS AT PAD

CURRENT SRB/SSV EXCURSIONS AT THREE SELECTED INTERFACE LOCATIONS ARE PRESENTED HERE IN THE VEHICLE COORDINATE SYSTEM. DISPLACEMENTS ARE FOR STEEL CASE SRB's AND INCLUDE VEHICLE TOLERANCES, PAYLOAD WEIGHTS (ZERO AND 65K LB), WIND LOADS, ET TANKING, SRB JOINT FREEPLAY AND SSME IGNITION AND SHUTDOWN. THESE DATA ARE TAKEN FROM "DYNAMIC WORST-CASE EXCURSIONS" DEVELOPED BY ROCKWELL IN STRUCTURAL DESIGN LOADS DATA BOOK, VOL. 7, JULY 1988 (STS 85-0169).

OTHER INTERFACE LOCATIONS WHERE DISPLACEMENTS ARE DEFINED ARE INDICATED ON THE ILLUSTRATION IN THE NEXT CHART. THESE COMPUTED EXCURSIONS CORRESPOND TO THE SSV WITH FIRST MODE FREQUENCY OF 0.29 HZ AND SECOND MODE OF 0.44 HZ. IF LRB CHARACTERISTICS DROP BELOW THESE LEVELS MOST DYNAMIC EXCURSIONS WILL BE SIGNIFICANTLY HIGHER. THIS COMPOUNDS THE DIFFICULTY OF GROUND INTERFACE REDESIGN.

BASELINE VEHICLE EXCURSIONS AT PAD

FUNCTION	TIMING	LOCATION	(INCHES)* X	Y	Z
GOX VENT	T-2 MIN	ET TIP	+4.6 +0.2	+1.4 -1.9	+16.2 -3.8
GH2 VENT	T-0	ET FWD INTERTANK	+3.6 -0.6	+1.8 -2.9	+17.5 -22.7
TSM	T-0	ORB AFT	+7.1 -11.1	+2.4 -3.1	+2.0 -1.5

* MAXIMUM POSITIVE AND NEGATIVE MOTION IN VEHICLE COORDINATE SYSTEM (SEE ILLUSTRATION)

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LIQUID ROCKET BOOSTER INTEGRATION SECOND PROGRESS REVIEW

OCT 88

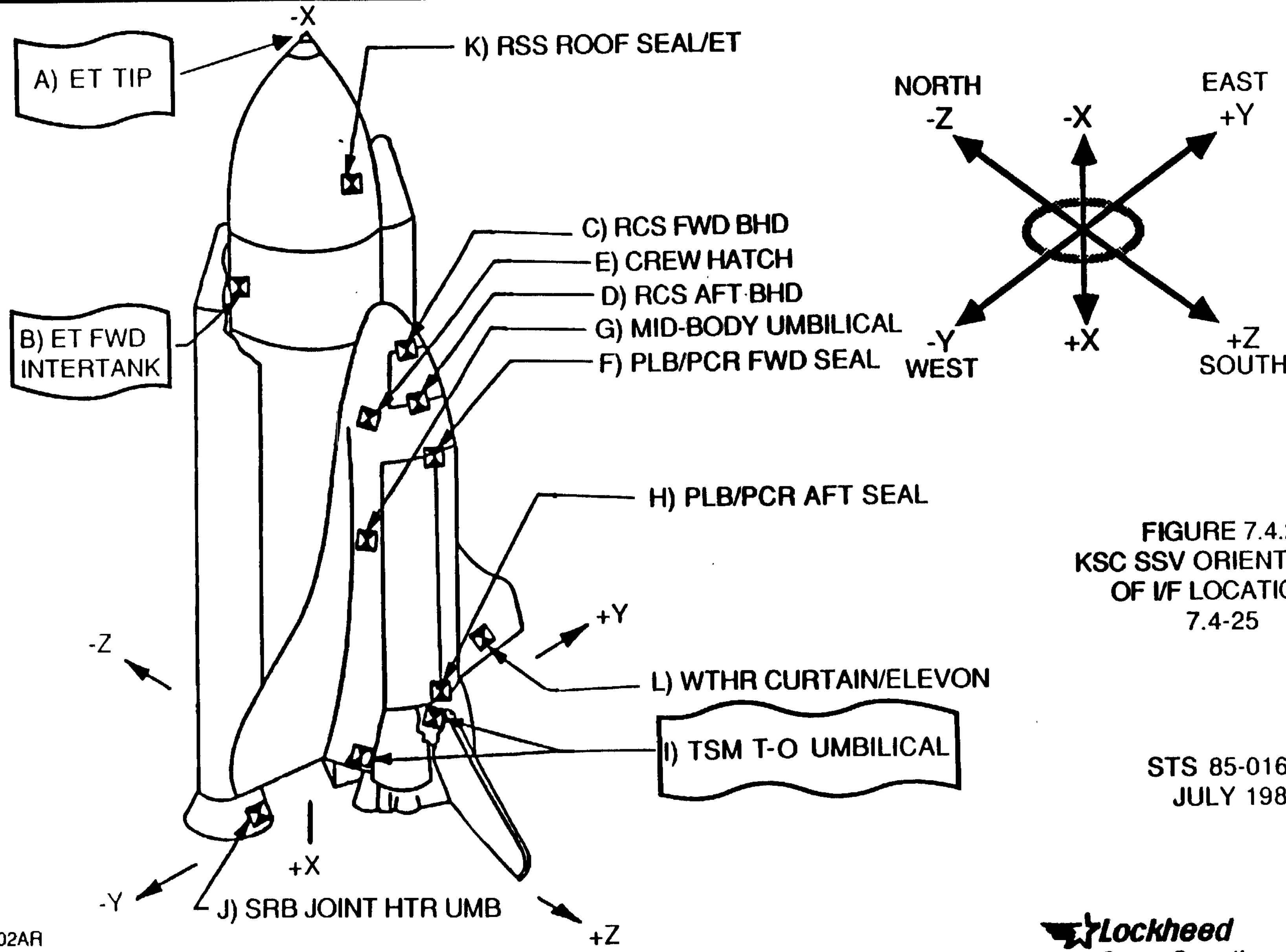

FIGURE 7.4.2
KSC SSV ORIENTATION
OF I/F LOCATIONS
7.4-25

STS 85-0169-7
JULY 1988

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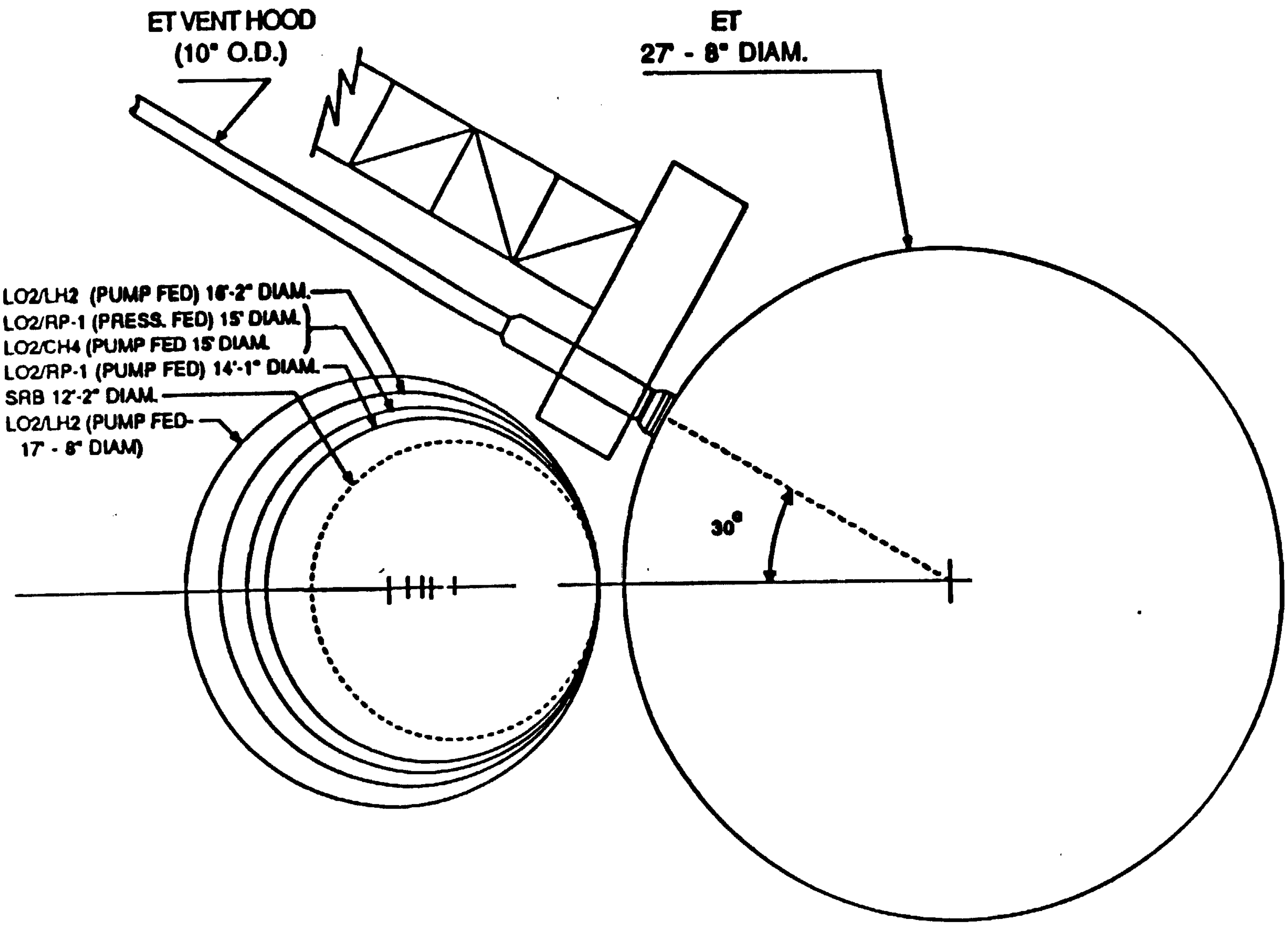
LRB/ET GH_2 VENT ARM CLEARANCE

OCT 88



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COORDINATION OF PHASE A COST ESTIMATES

- MMC AND GDSS COST SUMMARIES

- KSC COST ASSESSMENT STATUS
  - 10 MAY 88 EXERCISE
  - DETAILED BOTTOMS-UP (IN WORK)

- GROUND OPERATIONS COST MODEL (GOCM)

COMPARISON OF KSC LAUNCH SITE LCC COST ESTIMATES

THESE ROM DATA REPRESENT BEST CURRENT ESTIMATES OF BOTH RECURRING AND NON-RECURRING LRB LAUNCH SITE COSTS FOR THE 122-MISSION MODEL.

- "LCC LAUNCH OPERATIONS" COVERS RECURRING MANPOWER COSTS OF ALL DIRECT AND SUPPORTING CONTRACTORS PLUS BOOSTER-SUPPORTING CIVIL SERVICE PERSONNEL AT THE LAUNCH SITE.
- "FACILITIES, GSE/LSE" COST COVER ALL LAUNCH SITE EQUIPMENT AND FACILITIES REQUIRED TO SUPPORT THE FULL LRB FLIGHT RATE OF 14 PER YEAR.
- MMC IS CONCURRING WITH LSOC LAUNCH OPERATIONS COST.
- TOTAL LCC SHOWN HERE DOES NOT INCLUDE 40% NASA LOAD FACTOR.
- ALL COSTS SHOWN HERE ARE BASED ON MAY 88 ESTIMATES
- LSOC FACILITY COST ELEMENT ESTIMATES INCLUDE:

  1) FIRST LINE FACILITIES ($293M)

     - MLP (121M), HPF (59M), VAB/HB 4 (19M), PAD (60M), LETF/LCC (14M), GRD S/W (20M)

  2) SECOND LINE FACILITIES ($183M)

     - MLP (109M), VAB/HB3(6M), PAD (60M), LETF/LCC(8M)

COMPARISON OF KSC LAUNCH SITE LCC COST ESTIMATES

TEAM	FACILITIES, GSE/LSE $ (M)	LCC LAUNCH OPERATIONS $ (M)	TOTAL LCC COST $ (M)
GD	337	758	1095
MMC	324	501*	825
LSOC	476	501	977

NOTE: COSTS DO NOT INCLUDE 40% NASA LOAD FACTOR

* MMC IS CONCURRING WITH LSOC LAUNCH OPS COST ESTIMATE

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3. ALTERNATE LRB APPLICATIONS

- GDSS AND MMC ACTIVITIES
- LAUNCH SITE REQUIREMENTS FOR ALS
- MIXED FLEET OPERATIONS
- CANDIDATE PAD "C" CONCEPTS

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GENERAL DYNAMICS
Space Systems Division

TOP LEVEL REQUIREMENTS FOR ALTERNATE LRB APPLICATIONS (2.0)

LRB

REQUIREMENT \ APPLICATION	STS LRB	ALS	SHUTTLE "C"	STANDALONE	SHUTTLE "II"
PAYLOAD (LBS)	70.5 K (160nm,28.5°)	160 K (80x150nm,90°)	102 K (220nm,28.5°)	< 60 K (150nm,28.5°)	20 K (262nm,28.5°)
PERFORMANCE (TOTAL BOOSTER IMPULSE)	500 M LBSEC	640 M LBSEC	500 M LBSEC	250+ M LBSEC	730 M LBSEC
MAN - RATED	YES	NO*	NO	NO	YES
FLIGHT RATE/YEAR	14	20-30	2-3	(TBD)	~25
ENGINE - OUT	YES	YES	YES	(TBD)	YES
BOOSTER REUSABILITY	NO	(TBD)	(TBD)	NO	YES
IOC	1995	1998	1993	1995 -1996	2005

* WILL EXAMINE MAN-RATED DERIVATIVE

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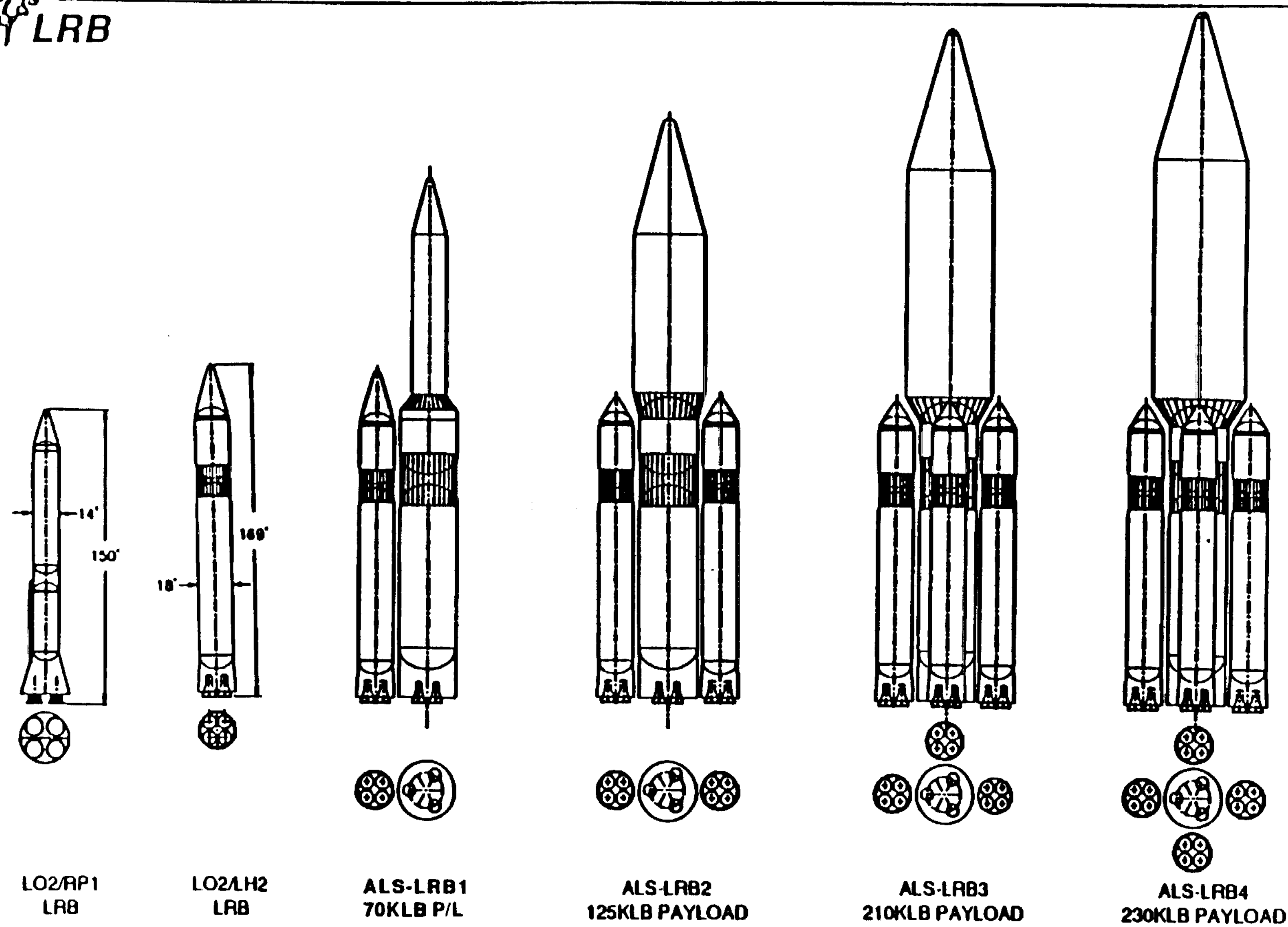
GENERAL DYNAMICS
Space Systems Division

APPLICATIONS OF WHOLE LRB ON ALS

LRB



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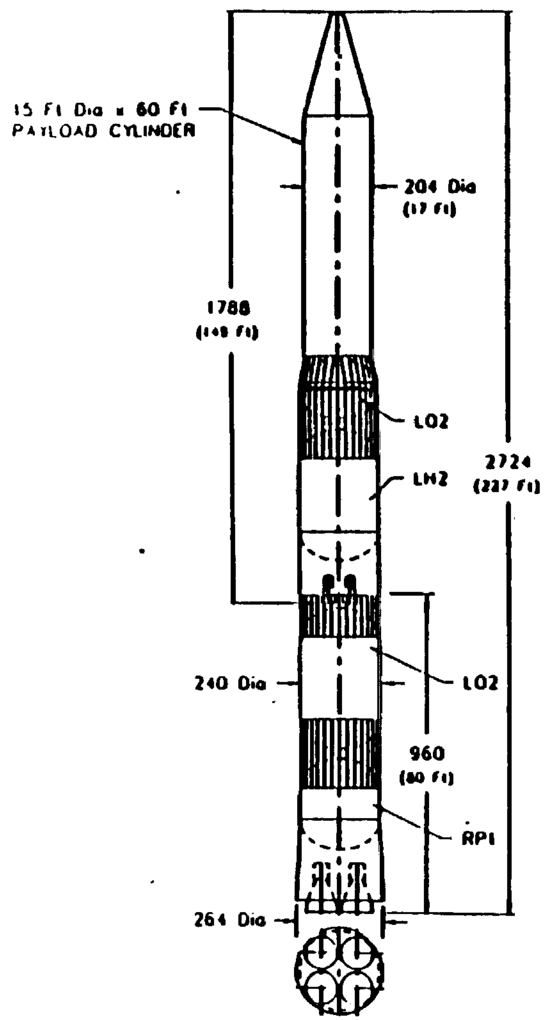
GENERAL DYNAMICS
Space Systems Division

STANDALONE LRB (4B)

LRB



UPPER STAGE	
GROSS WEIGHT	359,965 Lbs
THRUST	469,923 Lbs
T/W AFTER SEP	1.326
P/L TO ORBIT	40K Lbs
BOOSTER	
GLOW	1,370,725 Lbs
THRUST	1,933,911 Lbs
T/W AT LIFTOFF	1.411

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Lockheed
Space Operations Company

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LAUNCH SITE REQUIREMENTS FOR ALS

- REQUIREMENTS DEFINITION
  - PROCESSING
  - LAUNCH OPERATIONS
  - RECOVERY OPS
- CANDIDATE SCENARIOS FOR EFFICIENT GROUND OPS CONCEPTS
  - PAYLOAD CANNISTER/SHROUD FLOW
  - CORE VEHICLE FLOW
  - BOOSTER OPTIONS/PROCESSING APPROACHES
  - VEHICLE INTEGRATION PLAN
- FACILITIES PLAN
  - HORIZONTAL VS VERTICAL PROCESSING
  - MLP (YES/NO)
  - VAFB LAUNCH SITE OPTIONS
  - PAD "C" CONCEPTS AT KSC
  - ALS GSE/LSE
  - SHARED STS FACILITIES
- LAUNCH SITE INTEGRATION MUST BE MERGED WITH ALS SYSTEM DESIGN TO ENSURE CONTROL OF LIFE CYCLE COST ELEMENTS

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SHUTTLE "C" FLOW SUMMARY

- THE SHUTTLE "C" LAUNCH SITE PROCESSING SCENARIO CONTAINS SIGNIFICANT NEW FACILITY ACTIVATION REQUIREMENTS

- SHOWN HERE IS THE FAVORED "SIDEMOUNT" PROCESSING FLOW ILLUSTRATING THE MAJOR NEW AND MODIFIED FACILITIES:

  - CARGO CARRIER/PAYLOAD PROCESSING BLDG.
  - NEW SRB BUILD-UP AND STACKING FACILITY (REMOTE STACKING)
  - EXPANDED OR NEW RPSF/SURGE FACILITY

- ESTIMATED SHUTTLE "C" LAUNCH SITE FACILITY CHANGES TOTALLED $320 M IN A FEB 1988 NASA ASSESSMENT. A PRELIMINARY COMPARISON USING LRB IS IN WORK.

- SIGNIFICANT REDUCTION IN THIS LAUNCH SITE IMPACT COULD BE REALIZED THRU THE APPLICATION OF LRB TO THE SHUTTLE "C" SYSTEM.

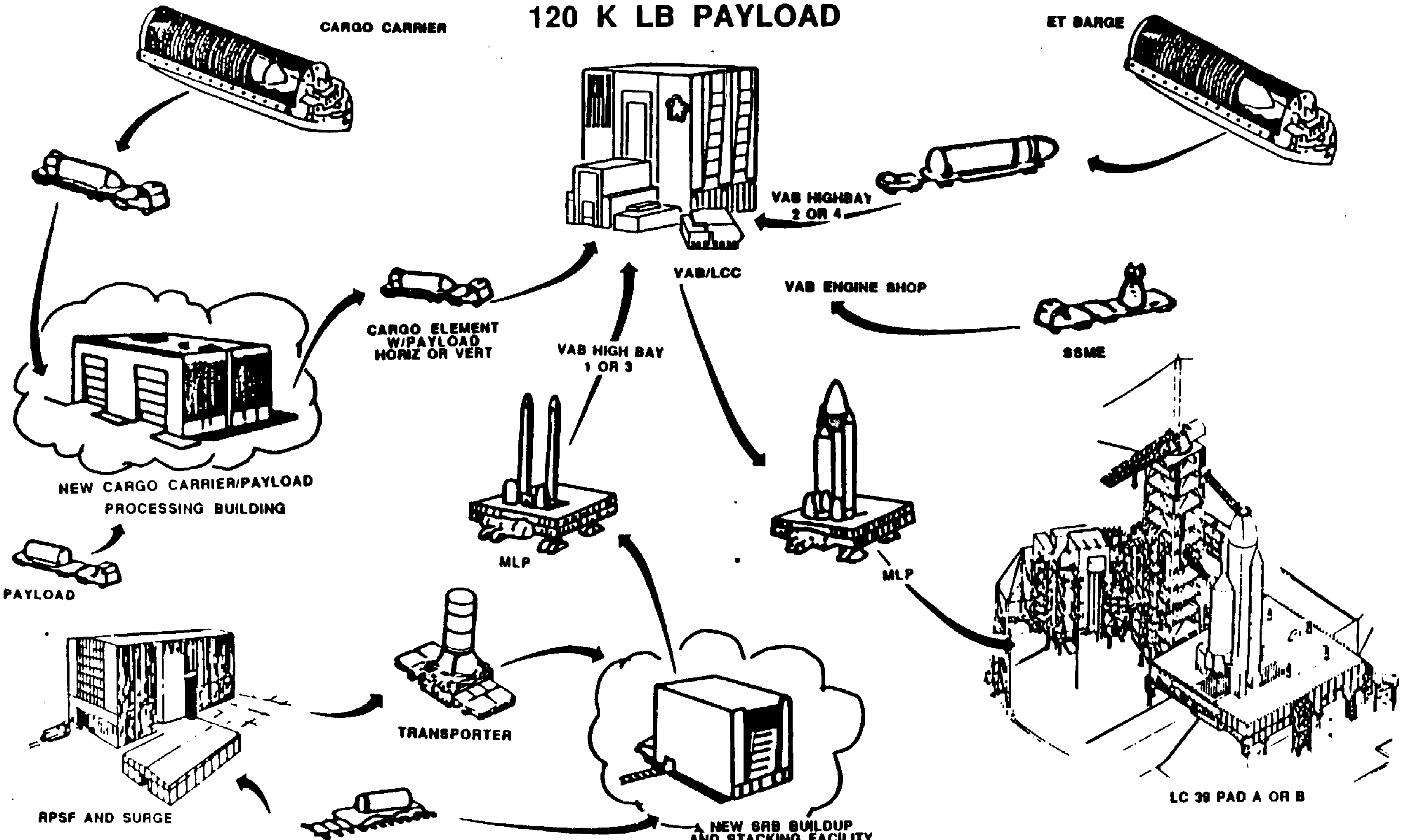
- THE MAJOR FACTORS ARE: 1) THE ELIMINATION OF THE REQUIREMENT FOR THE REMOTE STACKING FACILITY, 2) NO NEW OR EXPANDED RPSF/SURGE, AND 3) LOWER RISK OF IMPACT TO ON-GOING STS LAUNCH OPERATIONS.

KSC ADVANCED PROJECTS & TECHNOLOGY OFFICE

SHUTTLE-C FLOW SUMMARY (SIDEMOUNT WITH SRB)

OCTOBER 1988

120 K LB PAYLOAD



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GROUND OPS STUDY INTEGRATION

- MSFC PHASE A CONTRACT EXTENSIONS
  - LRB DESIGN OPTIMIZATION
  - LRB ALTERNATE APPLICATIONS
  - PRESSURE-FED ENGINE TEST BED SUPPORT
- LAUNCH SITE DESIGN RECOMMENDATIONS
  - UPDATE AND CONTINUE
- LIFE CYCLE COST ASSESSMENTS
  - CONTINUE REFINEMENTS
  - FINALIZE AND DOCUMENT

LIQUID ROCKET BOOSTER INTEGRATION SECOND PROGRESS REVIEW

OCT 1988

AGENDA

I. INTRODUCTION	Gordon Artley
II. STUDY PROGRESS	
A. ACHIEVEMENT SUMMARY	Pat Scott
B. ENGINE PROCESSING STUDY	Glen Waldrop
C. LRB/ET PROCESSING EVALUATION	Greg DeBlasio
D. SAFETY & ENVIRONMENTAL IMPLICATIONS	Roger Lee
E. GOCM STATUS	Stephen Schneider
III. SUMMARY	Gordon Artley

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- **<u>LRB ENGINE PROCESSING CONSIDERATIONS</u>**
  - ENGINE CHARACTERISTICS
  - OPERATIONS
  - FACILITIES / EQUIPMENT
  - PROCESSING FLOW

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LRB ENGINE CHARACTERISTICS

- PROPELLANTS
  - LOX/RP-1 -- PRESSURE & PUMP FED
  - LOX/LH2 -- PUMP FED
- GAS REQUIREMENTS
  - NITROGEN
  - HELIUM
- ELECTRIC ACTUATORS
- SUPERVISORY CONTROLLER
- PHYSICALS / ENGINE WEIGHT
  - LOX/RP-1 -- PRESSURE -- 5700LB
  - LOX/RP-1 -- PUMP -- 8100LB
  - LOX/LH2 -- PUMP -- 6700LB
  - SIMILAR TO SSME IN SIZE
  - SSME: HT = 168", EXIT DIA = 90"
- EXPENDABLE

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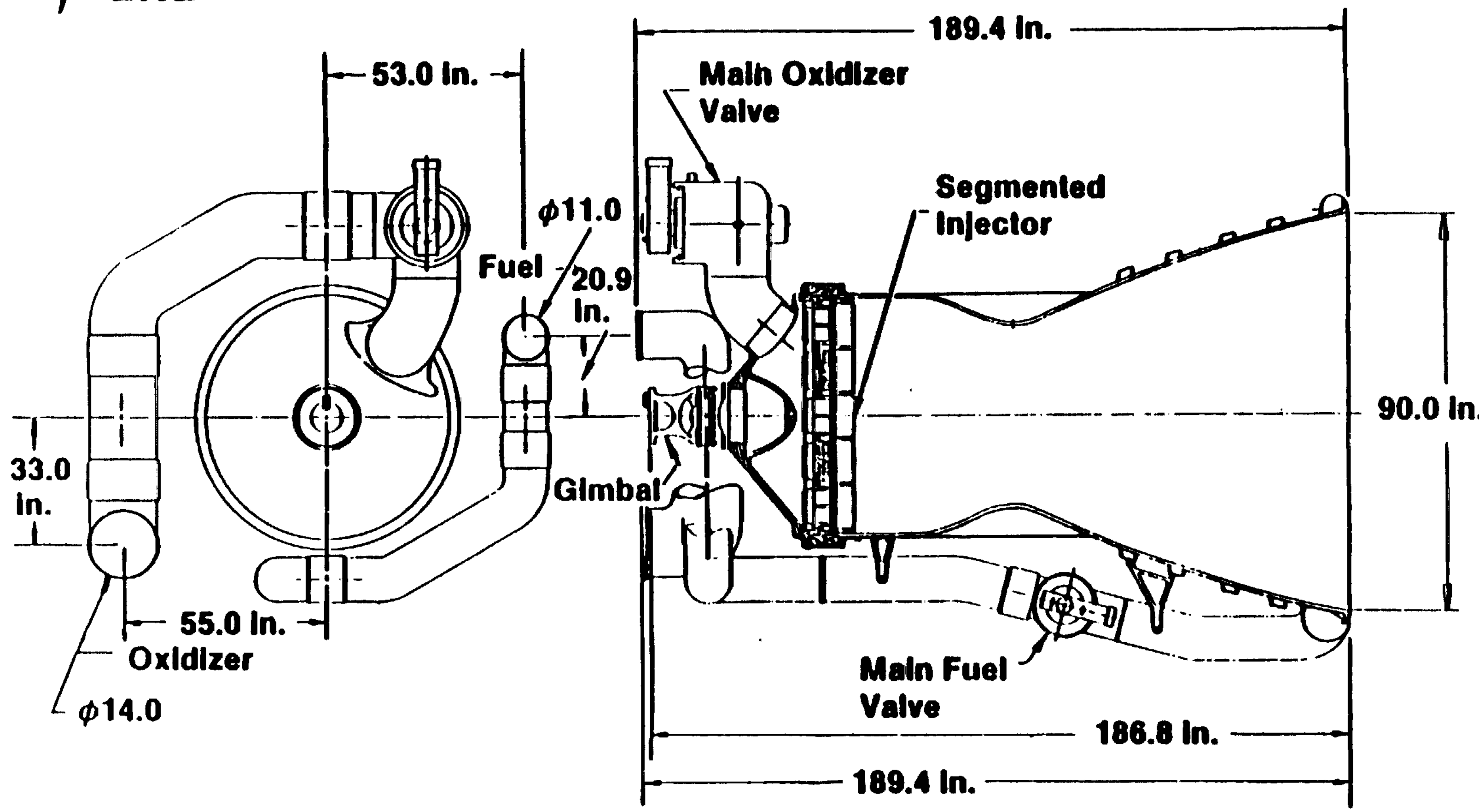
GENERAL DYNAMICS
Space Systems Division

LRB Pressure-Fed LOX/RP-1 Engine System

LRB



Rockwell International
Rocketdyne Division

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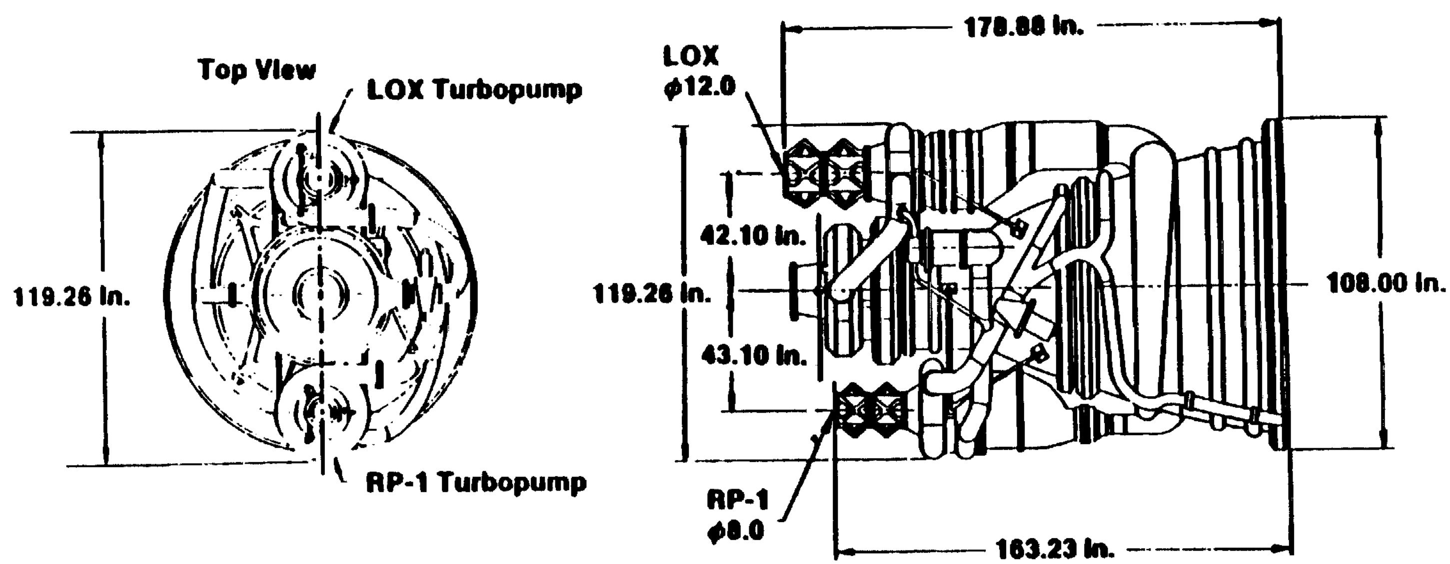
LRB LOX/RP-1 Pump-Fed Engine

LRB



Rockwell International
Rocketdyne Division

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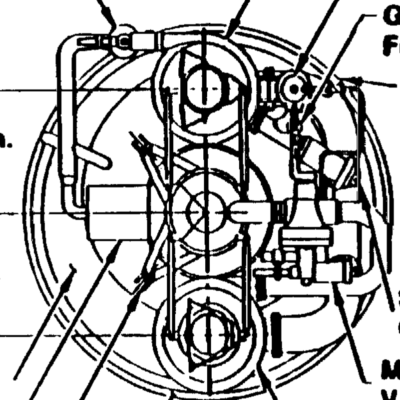
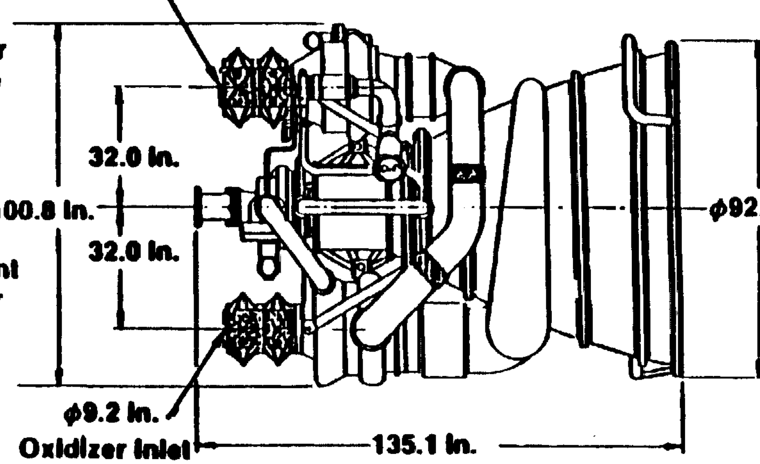
GENERAL DYNAMICS
Space Systems Division

LRB LOX/Hydrogen Engine

LRB



View A-A



Rockwell International
Rocketdyne Division

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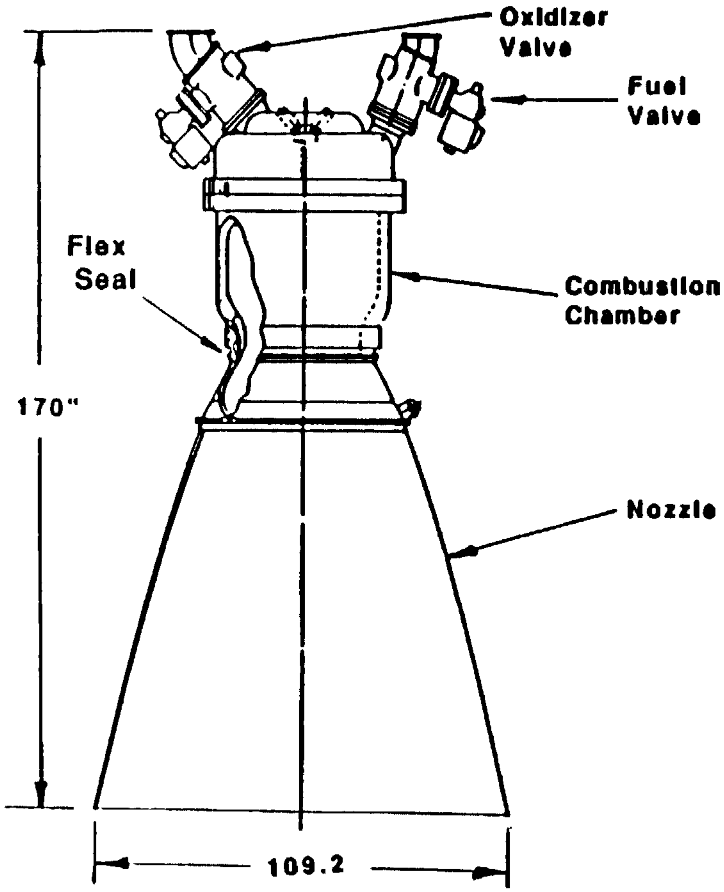
LRB PRESSURE FED ENGINE
LO2/RP1



	NPL	FPL
Thrust, S.L. klbs	562	750
Thrust, Vac klbs	700	887
ISP, S.L. sec	257	271
ISP, Vac, sec	321	321
Mixture Ratio	2.7	2.7
Total Flow Rate, lb/sec	2185	2766
Chamber Pressure, Psia	630	800
Exit Pressure, Psia	5.5	6.9
Expansion Ratio	15.4	
Chamber Type	Ablative	
Nozzle Type	Ablative	
Weight, Dry, lbs	4500	
Propellants	LO2/RP1	
Gimbal Angle	±6°	
Gimbal Type	Head End Flex Seal (Optional)	
Throttle Range	65 - 100%	

LRB 3/7 01

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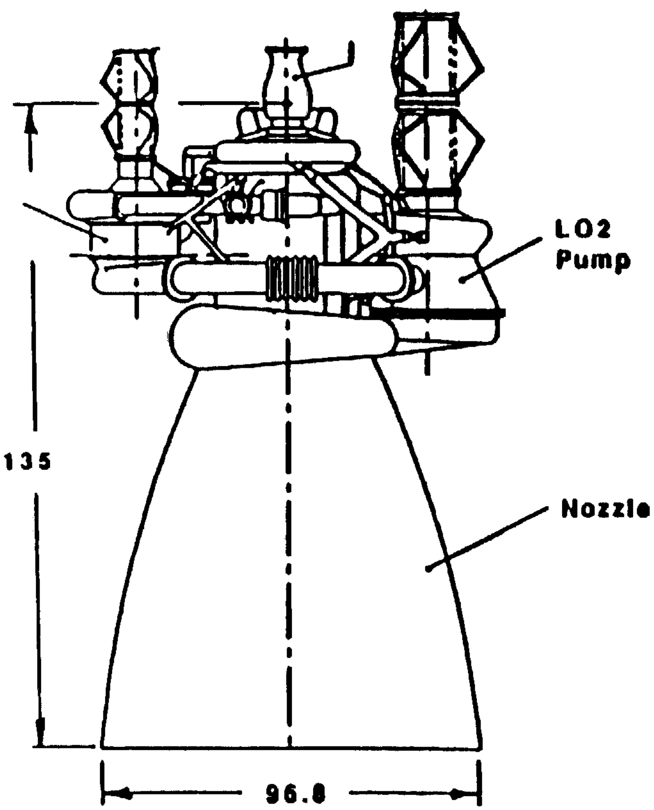
Aerojet TechSystems Company

LRB PUMP FED ENGINE
LO2/RP1



	NPL	EPL
Thrust, S.L. klbs	513	685
Thrust, Vac. kbs	623	788
ISP, S.L. sec	265	277
ISP, Vac, sec	322	318
Mixture Ratio	2.6	2.5
Total Flow Rate, lb/sec	1933	2473
Chamber Pressure, Psia	1033	1300
Exit Pressure, Psia	5.9	7.7
Expansion Ratio	21.2	
Nozzle Type	Carbon-Carbon	
Weight, Dry, lbs	6807	
Engine Cycle	Gas Gen	
Propellants	LO2/RP1	
Gimbal Type	Head End	
Gimbal Angle	±6°	
Throttle Range	65 - 100%	

LRB 3/7 02a

LRB ENGINE PROCESSING OPERATIONS

THE LRB ENGINE PROCESSING OPERATIONS HAVE BEEN BROKEN DOWN INTO FOUR BASIC CATEGORIES: HARDWARE HANDLING, HARDWARE REPLACEMENT (FROM ENTIRE ENGINE DOWN TO THE COMPONENT LEVEL), VERIFICATION OF ENGINE FUNCTIONAL INTEGRITY, AND, THE FINAL CLOSEOUT ITEMS REQUIRED FOR THE LAUNCH PHASE OF THE OPERATION.

SINCE THE LRB, AND ITS PROPULSION SYSTEM REMAINS IN A CONCEPTUAL DESIGN STAGE, DETAILED DEFINITION OF ALL OF THE GSE TO SUPPORT ALL THE PROCESSING OPERATIONS WAS VIRTUALLY IMPOSSIBLE AT THIS WRITING. HOWEVER, BY UTILIZING THE BASIC CONCEPTS PRESENTED BY THE VEHICLE, PROPULSION, AND LAUNCH SITE INTEGRATED CONTRACTORS, THE GENERAL OPERATIONAL CHARACTERISTICS AND CONFIGURATION CAN BE DEFINED FOR THE MAJOR GSE REQUIRED TO SUPPORT THE PROCESSING OF THE LRB ENGINES. THE PROJECTED SIZE AND WEIGHT OF THE ENGINE, AND THE INTENDED COMPLETED PROCESSING OF THE SYSTEM IN BOTH THE HORIZONTAL AND VERTICAL POSITIONS (USING THE SAME BASIC NON-INTEGRATED AND INTEGRATED CONFIGURATION AND EQUIPMENT AS THE STS) DRIVES THE LRB ENGINE PROCESSING SIMILARITY TO THE PROCESSING CHARACTERISTICS OF THE SPACE SHUTTLE MAIN ENGINE.

- <u>LRB ENGINE PROCESSING OPERATIONS</u>
  - HANDLING
  - CHANGEOUT / LRU LEVEL
  - CHECKOUT
  - SERVICING FOR LAUNCH

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LIQUID ROCKET BOOSTER INTEGRATION SECOND PROGRESS REVIEW

OCT 1988

LRB ENGINE PROCESSING EQUIPMENT

FACILITY SUPPORT

ITEM	SIMILAR CURRENT UNIT	DESCRIPTION
ACCESS PLATFORMS VEHICLE VERTICAL	A70 - 0663 A70 -	USED TO REMOVE/INSTALL ENGINES
ACCESS PLATFORMS VEHICLE HORIZONTAL	OPF AFT PLATF	
ACCESS PLATFORMS ENGINE SHOP	A70 - A70 -	
CHAMBER ENTRY MANLIFT	N/	
MASS SPECTROMETER STATION (FIXED)	N/	

SERVICE / CHECKOUT

ITEM	SIMILAR CURRENT UNIT	DESCRIPTION
ENVIRONMENTAL PROTECTION SET	S70 - 0902	SEAL ENGINE OPENINGS FOR ENVIRONMENTAL CONTROL
INTERNAL INSPECTION EQUIPMENT	C70 -	
TEST ADAPTER SET	C70 -	
FLOW TESTER	C70-0 C70-0 C70-0	
REGULATOR PANELS	C70-07	
REGULATOR PANELS	S70 - S70 - S72 -	
ENGINE FLUSH & DRYING UNIT CHAMBER SERVICING	N/A	
THERMAL PROTECTION SYSTEM WELDER	N/A	
ENGINE COMMAND AND DATA SIMULATOR	N/A	

ENGINE HANDLING

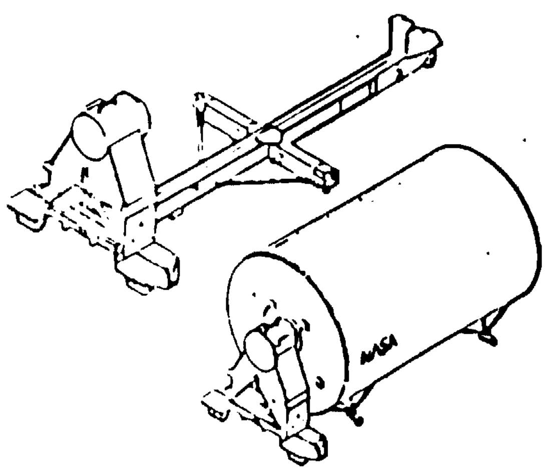
ITEM	SIMILAR CURRENT UNIT	DESCRIPTION
HYSTER LIFT TRUCK	H70-0764	INSTALL/REMOVE ENGINE - HORIZONTAL
HORIZONTAL INSTALLER	H70-0568	INSTALL/REMOVE ENGINE - HORIZONTAL
ENGINE HANDLER	H70-0901	SHIP/STORE AND HORIZONTAL PROCESSING
ENGINE HANDLER SLING	H70-0902	LOAD/UNLOAD ENGINE HANDLER
INTERFACE SUPPORT PANEL	H70-0911	ENGINE SUPPORT WITH HANDLER AND ROTATING SLING
ROTATING SLING	H70-0903	ROTATE ENGINE TO VERTICAL
VERTICAL INSTALLER	H70-0774	INSTALL/REMOVE ENGINE - VERTICAL
PROOFLOAD FIXTURE SET	S70-0911	PROOFLOAD/CRITICAL LIFT OF HANDLING EQUIPMENT
ENGINE MOVER SET	H70-0890	MOVE ENGINE WITHOUT TVC ACTUATORS
ENGINE ALIGNMENT SET	A70-0645	SETTING OF TVC ACTUATORS
COMPONENT HANDLER SET	H70-0905	USED WHEN LIFTING LRU'S
ENGINE LRU INSTALL/ REMOVAL SET	H70-0528	INSTALL/REMOVE LRU WITH VEHICLE IN EITHER HORIZONTAL OR VERTICAL
ENGINE/HANDLER MOVER	N/A	MOVE ENGINE/HANDLER IN SHOP AREAS
ENGINE DOLLY (VERTICAL)	N/A	USED TO PROCESS ENGINE IN VERTICAL
TVC ACTUATOR LOCKS TVC ACTUATOR SUPPORTS TVC ACTUATOR EXTEND/ RETRACT LOCKS	A70-0501 H70-0628 A70-0983	USED TO MAINTAIN ENGINE IN DESIRED FIXED POSITION WHEN ENGINE INSTALLED IN VEHICLE

LRB ENGINE HANDLING
LRB ENGINE/LRU CHANGEOUT

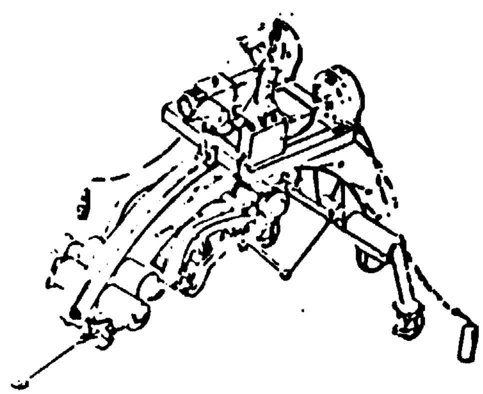
THE GROUND SUPPORT EQUIPMENT (GSE), REALIZED AT THIS TIME TO SUPPORT THE LIQUID ROCKET BOOSTER ENGINE OPERATIONS HAS BEEN ARBITRARILY GROUPED INTO THREE (3) OPERATIONAL CATEGORIES. THESE OPERATIONAL CATEGROIES WOULD INCLUDE: A) ENGINE HANDLING, B) CHECKOUT/SERVICING, AND C) FACILITY SUPPORT.

THE ENGINE HANDLING CATEGORY WOULD INCLUDE ALL ENGINE, AND ENGINE COMPONENT, MOVEMENT AND SUPPORT. SUCH ACTIVITIES AS RECEIVING/SHIPPING AN ENGINE, ENGINE PREPARATION FOR VEHICLE INSTALLATION AND REMOVAL, ENGINE INSTALLATION AND REMOVAL, AND, COMPONENT HANDLING/INSTALLATION/REMOVAL WOULD BE INCLUDED IN THIS CATEGORY.

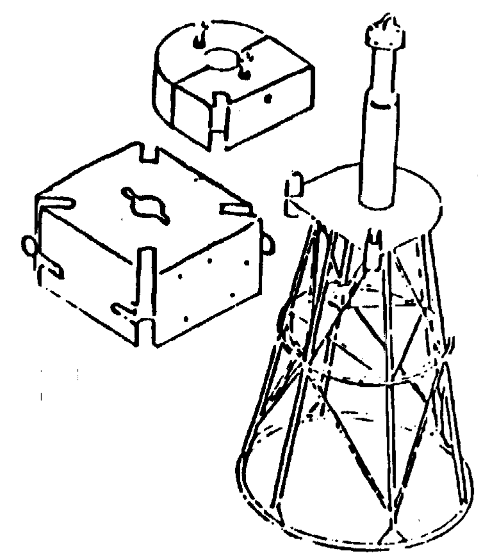
LRB ENGINE HANDLING



ENGINE HANDLER



ROTATING SLING



PROOF LOADING

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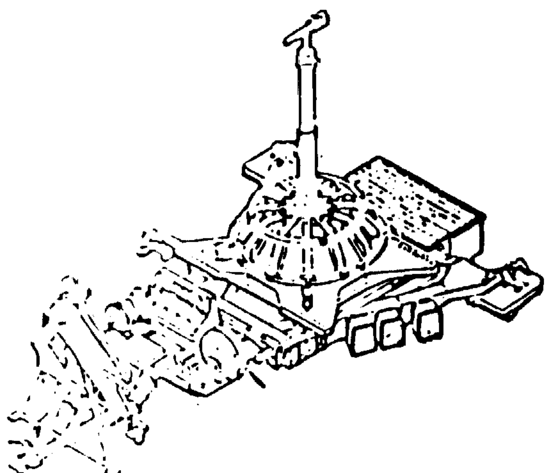
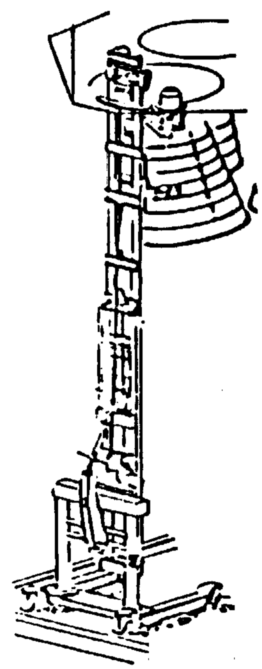
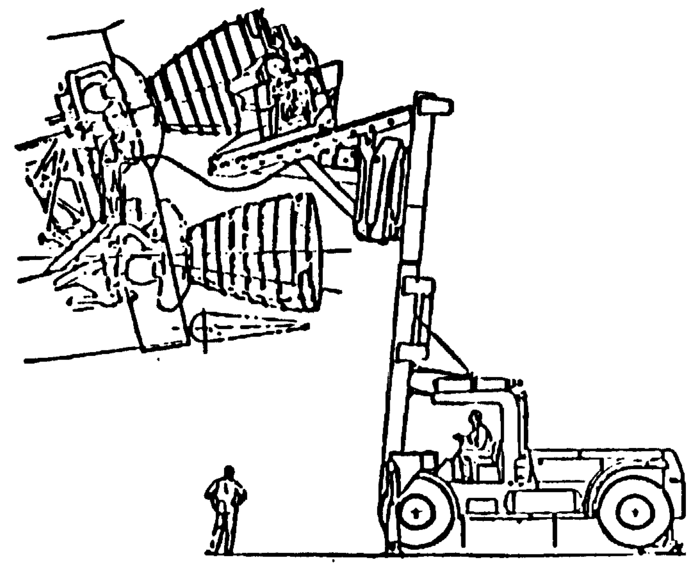
LRB ENGINE/LRU CHANGEOUT



VERTICAL INSTALLER



COMPONENT
LRU GSE



HORIZONTAL INSTALLER

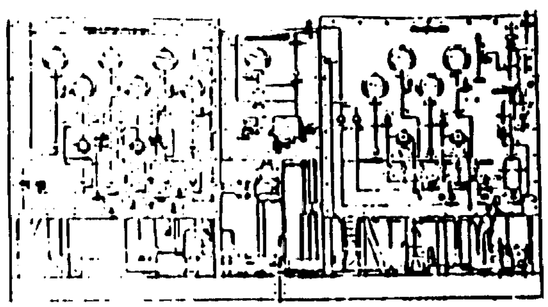
LRB ENGINE CHECKOUT/SERVICING

ENGINE CHECKOUT AND SERVICING WOULD INCLUDE SUCH ITEMS AS ENGINE PROTECTION, INSPECTION, ALL MECHANICAL/FLUID/ELECTRICAL CHECKOUTS, AND THE SERVICING AND "CLOSEOUT" REQUIREMENTS FOR LAUNCH.

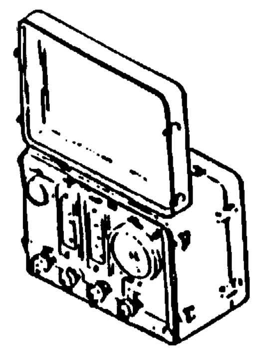
LIQUID ROCKET BOOSTER INTEGRATION SECOND PROGRESS REVIEW

OCT 1988

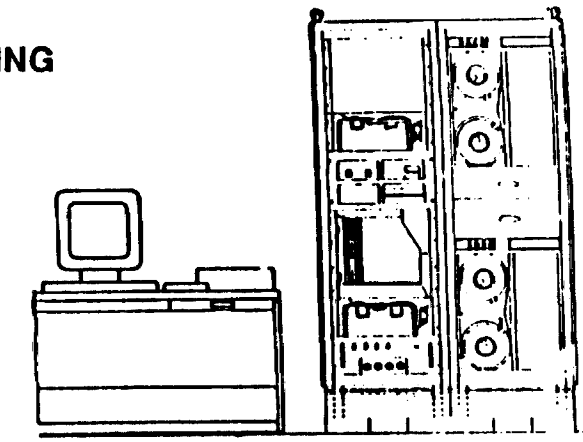
LRB ENGINE CHECKOUT/SERVICING



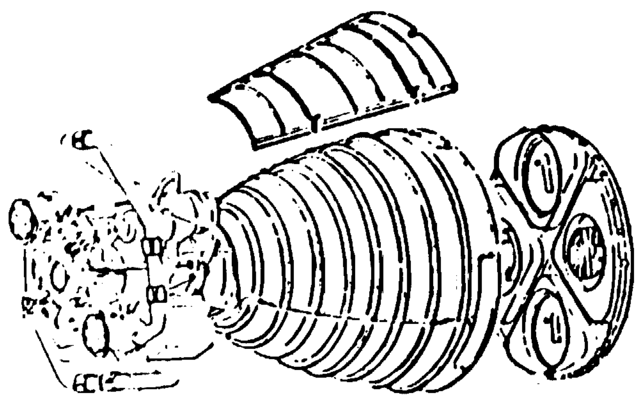
LEAK & FUNCTIONALS



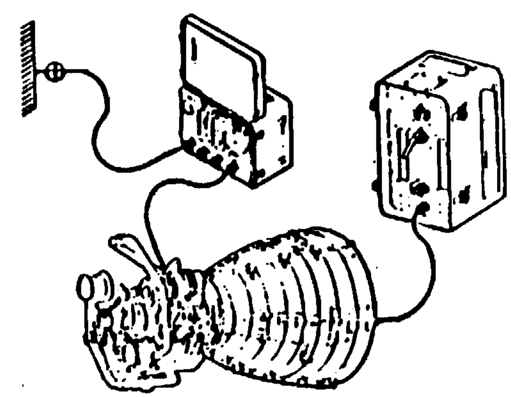
FLOW



ELECTRONIC



TEST & PROTECTIVE COVERS



LAUNCH PREPARATION

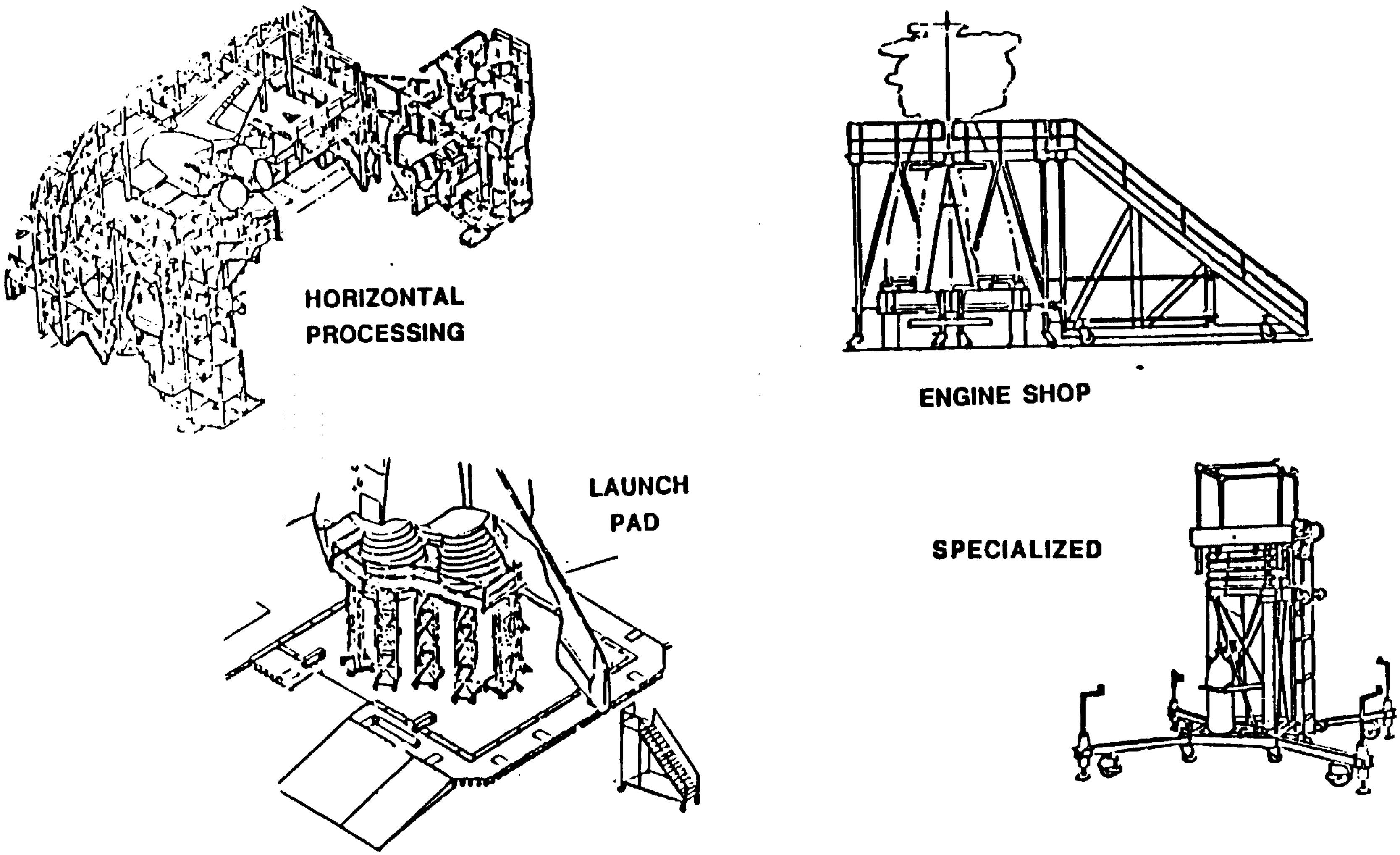
LRB ENGINE ACCESS REQUIREMENTS

TOTAL AND EASE OF ACCESS TO THE ENGINES IS A MUST FOR EFFICIENT AND EFFECTIVE PROCESSING OPERATIONS. "LESSONS LEARNED" EVOLVING FROM THE SSME PROCESSING AT ALL AREAS OF LC-39 HAS BEEN USED TO PROMOTE CONCEPTS FOR THE LRB ENGINE ACCESS THAT SHOULD ENHANCE THE SAFETY FOR PERSONNEL AND FLIGHT HARDWARE, AND PROVE TO BE COST EFFECTIVE.

FACILITY SUPPORT DENOTES THE "FACILITIES" TYPE GSE REQUIRED TO INSURE THE PERFORMANCE OF THE FIRST TWO OPERATIONAL CATEGORIES MENTIONED ABOVE.

LIQUID ROCKET BOOSTER INTEGRATION SECOND PROGRESS REVIEW

OCT 1988



LRB ENGINE ACCESS REQUIREMENTS

LRB ENGINE PROCESSING FACILITIES

THE FACILITY REQUIREMENTS TO SUPPORT THE ENGINE RELATED PROCESSING ACTIVITIES OF THE LRB SHOULD BE CONFINED BASICALLY TO THE LRB HORIZONTAL PROCESSING FACILITY, LRB INTEGRATED PROCESSING AREA, AND, THE LAUNCH PAD. THE MAJOR PART OF THE ENGINE RELATED WORK WOULD BE CONDUCTED IN, AND FROM, THE LRB HORIZONTAL PROCESSING FACILITY. PRESENT BASELINES INDICATE THAT THE INTEGRATION FACILITY AND LAUNCH PAD WORK FOR THE ENGINES WOULD BE IN SUPPORT OF INTEGRATED CHECKOUT AND "CLOSEOUT" OPERATIONS FOR LAUNCH, RESPECTIVELY.

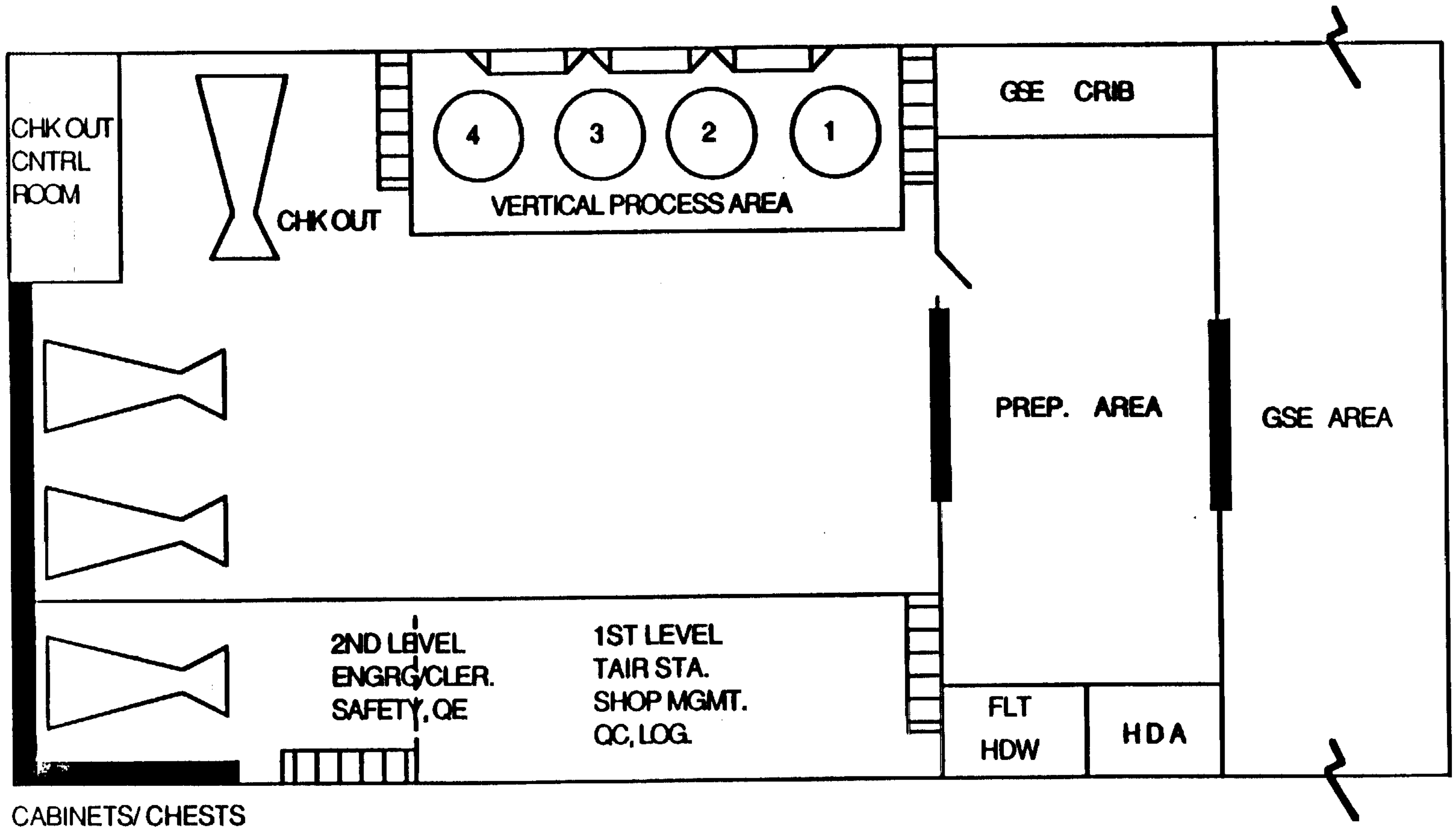
LRB ENGINE PROCESSING FACILITIES

- ENGINE SHOP
  - COMPONENT CHANGEOUT
  - SERVICING
  - CHECKOUT
  - GSE STAGING AREA
  - CENTRALIZED PERSONNEL
- VEHICLE AREA
  - ENGINE CHANGEOUT
  - SERVICING
  - TOTAL ACCESS

LRB HORIZONTAL PROCESSING FACILITY
LRB ENGINE SHOP

THE LRB ENGINE SHOP AREA WILL BE THE NUCLEUS FOR THE ENGINE RELATED PROCESSING OPERATIONS. THIS FACILITY SHOULD PROVIDE FOR THE RECEIPT, STORAGE, INSTALLATION/REMOVAL, MODIFICATION, CHECKOUT, AND MAINTENANCE OF THE ENGINES, AND, ANY RELATED OPERATIONS ASSOCIATED WITH THE GROUND SUPPORT EQUIPMENT NEEDED FOR ENGINE PROCESSING. USING THESE BASELINES, A GENERAL DESCRIPTION OF THE FACILITY CAN BE DEVELOPED TO SUPPORT ALL PHASES OF ENGINE PROCESSING AS DEFINED BY THE CONCEPTUAL DESIGN OF THE LRB PROPULSION SYSTEM.

LIQUID ROCKET BOOSTER INTEGRATION SECOND PROGRESS REVIEW



TYPICAL LRB ENGINE PROCESSING FACILITY

LRB ENGINE PROCESSING FACILITIES

VEHICLE AREA

IN ORDER TO EFFECTIVELY SUPPORT THE PROCESSING FLOW, "SATELLITE" AREAS AT THE INTEGRATION AND PAD LOCATIONS WILL BE NEEDED FOR THE LRB ENGINE OPERATIONS. THESE AREAS WILL BE USED AS STAGING AREAS FOR PERSONNEL, TOOLS, MINOR EQUIPMENT, AND MINOR FLIGHT HARDWARE.

OTHER AREA(S)

SOME PRESENT LRB ENGINE OPERATION CONCEPTS INDICATE THE USE OF PACKAGE IGNITION SYSTEM AND PYRO CARTRIDGES FOR INITIAL GAS GENERATOR OPERATION. SPECIAL AREAS WILL HAVE TO BE CONSIDERED FOR THESE DEVICES AND SHOULD BE EASILY ACCESSIBLE TO SUPPORT COST EFFECTIVE LAUNCH "CLOSEOUT" OPERATIONS.

LRB ENGINE PROCESSING FACILITIES

- VEHICLE AREA
  - INTEGRATION CELL
  - LAUNCHER PLATFORM
  - LAUNCH AREA

- OTHER AREA(S)
  - IGNITION PACKAGE STORAGE
  - GAS GENERATOR CARTRIDGE STORAGE

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LRB ENGINE PROCESSING FLOW

Task	Resources
ENGINE SHOP	
RECEIVING / DE-PACKAGE / INSPECTION	1 SHIFT * / 5 TECHS
PREPS FOR INSTALLATION / **HORIZONTAL PROCESSING FACILITY** / INSTALLATION / INTERFACE VERIFICATION	3 SHIFTS * / 5 TECHS
ENGINE ALIGNMENT VERIFICATION / GIMBAL PROFILE VERIFICATION / EXTERNAL LEAK CHECKS / INTERNAL LEAK CHECKS / FLOW CHECKS / ELECTRICAL CHECKOUT / INTEGRATED CHECKOUT	4 SHIFTS * / 11 TECHS
THERMAL PROTECTION SYSTEM INSTALLATION**	
INTEGRATED CONFIGURATION	
INTEGRATED TESTING/FRT	1 SHIFT / 2 TECHS
THERMAL PROTECTION SYSTEM INSTALLATION**	
LAUNCH PREPARATION: • IGNITION SYSTEM INSTALLATION • GAS GENERATOR CARTRIDGE INSTALLATION • FLUSH/DRY SYSTEMS • PREPARE FUEL SYSTEM (ANTI-FREEZE) • FINAL TPS INSTALLATION	1 SHIFT * / 14 TECHS

* PER ENGINE
** 18 SHIFT TOTAL - 10 TECHS

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Lockheed Space Operations Company

LIQUID ROCKET BOOSTER INTEGRATION SECOND PROGRESS REVIEW

OCT 1988

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REVIEW OF ACTIVITIES

THE FIRST PROGRESS REVIEW (JULY 1988) PRESENTED IMPACT ANALYSIS FOR EXISTING AND NEW FACILITIES BY STATION SET. THIS ANALYSIS AND REQUIREMENT DEFINITION IS CONTINUING. SINCE SCHEDULED COMPLETION OF THE ANALYSIS IS CLOSE TO THE FINAL PROGRESS REVIEW THE STATION SET REPORT WILL BE PRESENTED AT THAT TIME.

THIS PROGRESS REVIEW WILL CONCENTRATE ON THE SELECTED TOPIC OF THE EVALUATION OF USING THE VAB FOR PROCESSING AND STORAGE OF THE LRB.

REVIEW OF ACTIVITIES

- 1st PROGRESS REVIEW (JULY 1988) PRESENTED A NEW ET/LRB FACILITY CONCEPT
- DUE TO THE CONCERNS WITH THE RECOMMENDATION OF AN OFF-LINE LRB FACILITY AND RELOCATION OF ET PROCESSING TO AN OFF-LINE FACILITY THE SECOND PROGRESS REVIEW WILL PRESENT THE EVALUATION

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REVIEW OF ACTIVITIES (CONT)

DRIVERS FOR NEW FACILITIES

- INTRODUCTION OF LRB WITHOUT IMPACT TO EXISTING FACILITIES AND OPERATIONS
- ACTIVATION OF LRB FACILITIES WITHOUT IMPACT TO LAUNCH SCHEDULE OF 12 TO 14 STS/YEAR
- ACTIVATION OF LRB FACILITIES IMPACTS DUE TO SRB OPERATIONS IN VAB AND FLIGHT RATE REQUIREMENTS

NEW FACILITY REQUIREMENTS

- NEED FOR A THIRD INTEGRATION CELL SO NOT TO IMPACT SRB FLIGHTS
- NEED TO MOVE ETs OUT OF HB4 SO IT CAN BE USED AS THIRD CELL

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ET/LRB PROCESSING EVALUATION

1. HB2/4 SPACE UTILIZATION
2. FLIGHT ELEMENT FLOW PATHS THROUGH VAB
3. CRANE/LIFT OPERATION REQUIREMENTS
4. ACTIVATION SCHEDULE
5. NEW ET/LRB HORIZONTAL PROCESSING SITE LOCATION
6. ET/LRB PROCESSING CONSTRAINTS IN VAB HB2/4
   (CONCEPT EVALUATION)
7. ET/LRB REQUIREMENTS FOR STORAGE & PROCESSING
8. CONCLUSIONS

PRESENT HB-2 SPACE AVAILABLE

THE FOLLOWING AREAS ARE AVAILABLE FOR LRB PROCESSING AND STORAGE CELLS:

AREA 1: ATTACHED TO TOWER "A" ABOVE LEVEL 10 (112') 104-FEET BY 76-FEET (BETWEEN COLUMN LINES Q, U, 12, 16)

AREA 2: IN FRONT OF HIGH BAY DOOR ABOVE LEVEL 10 (112') 76-FEET BY 76-FEET (BETWEEN COLUMN LINES U, X, 12, 14)

THE FLOOR SPACE BELOW LEVEL 10 ON EITHER SIDE OF THE DOOR IS 76-FEET BY 38'FEET (BETWEEN COLUMN LINES U, X, 14, 16 AND U, X, 10, 12).

LIQUID ROCKET BOOSTER INTEGRATION
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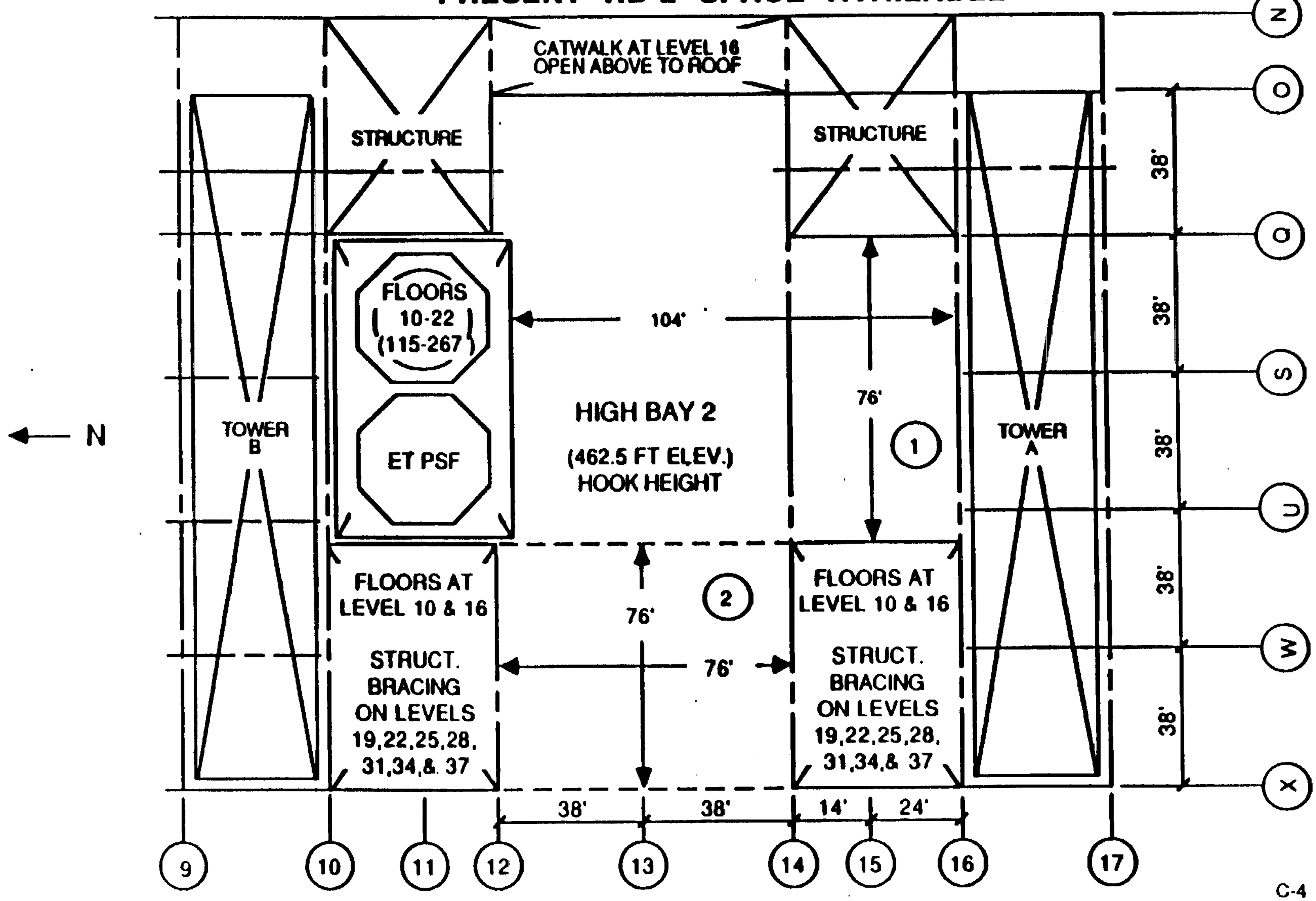
PRESENT HB-2 SPACE AVAILABLE



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CONCEPT FOR HI-BAY 2 SPACE UTILIZATION FOR TWO LRB CELLS

THE FOLLOWING TWO LOCATIONS ARE AVAILABLE:

- PROCESSING - AREA BETWEEN COLUMN LINES Q, U, 14, 15, ABOVE LEVEL 10 (ATTACHED TO TOWER "A")
- STORAGE - AREA BETWEEN COLUMN LINES U, X, 13, 14 ABOVE LEVEL 10 (IN FRONT OF HIGH BAY DOOR)

THIS ARRANGEMENT OF CELLS WILL PERMIT STORAGE OF A LRB FLIGHT PAIR AND PROCESSING OF A FLIGHT PAIR

HAVING THE CELLS ABOVE THE LEVEL 10 ELEVATION WILL ALLOW FOR VERTICAL ENGINE REMOVAL/INSTALLATION AND ACCESS TO THE HIGH BAY DOOR AND TOWER "A".

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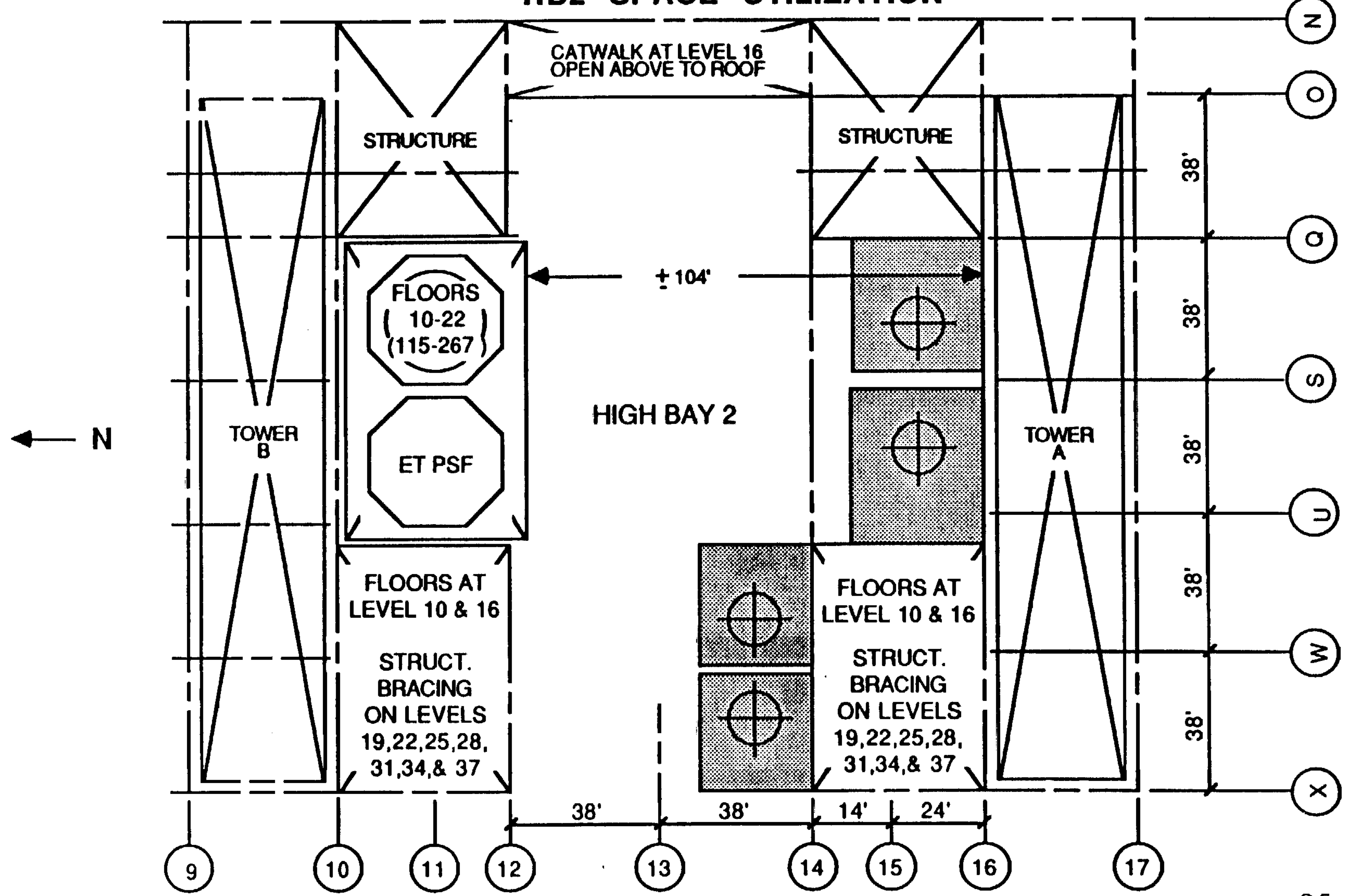
HB2 SPACE UTILIZATION



PRESENT HB-4 SPACE AVAILABLE

THE FOLLOWING AREAS ARE AVAILABLE FOR LRB PROCESSING AND STORAGE CELLS:

AREA 1: BETWEEN THE ET CELLS AND SRB WORK STANDS 66-FEET BY 76-FEET (BETWEEN COLUMN LINES Q, U, 5, 7)

AREA 2: IN FRONT OF HIGH BAY DOOR ABOVE LEVEL 10 (112') 76-FEET BY 76-FEET (BETWEEN COLUMN LINES U, X, 5, 7)

THE FLOOR SPACE BELOW LEVEL 10 ON EITHER SIDE OF THE DOOR IS 76-FEET BY 38-FEET (BETWEEN COLUMN LINES U, X, 3, 5 AND U, X, 7, 9)

THE SRB WORK STAND MUST REMAIN TO PROVIDE BACK-UP FOR RPSF.

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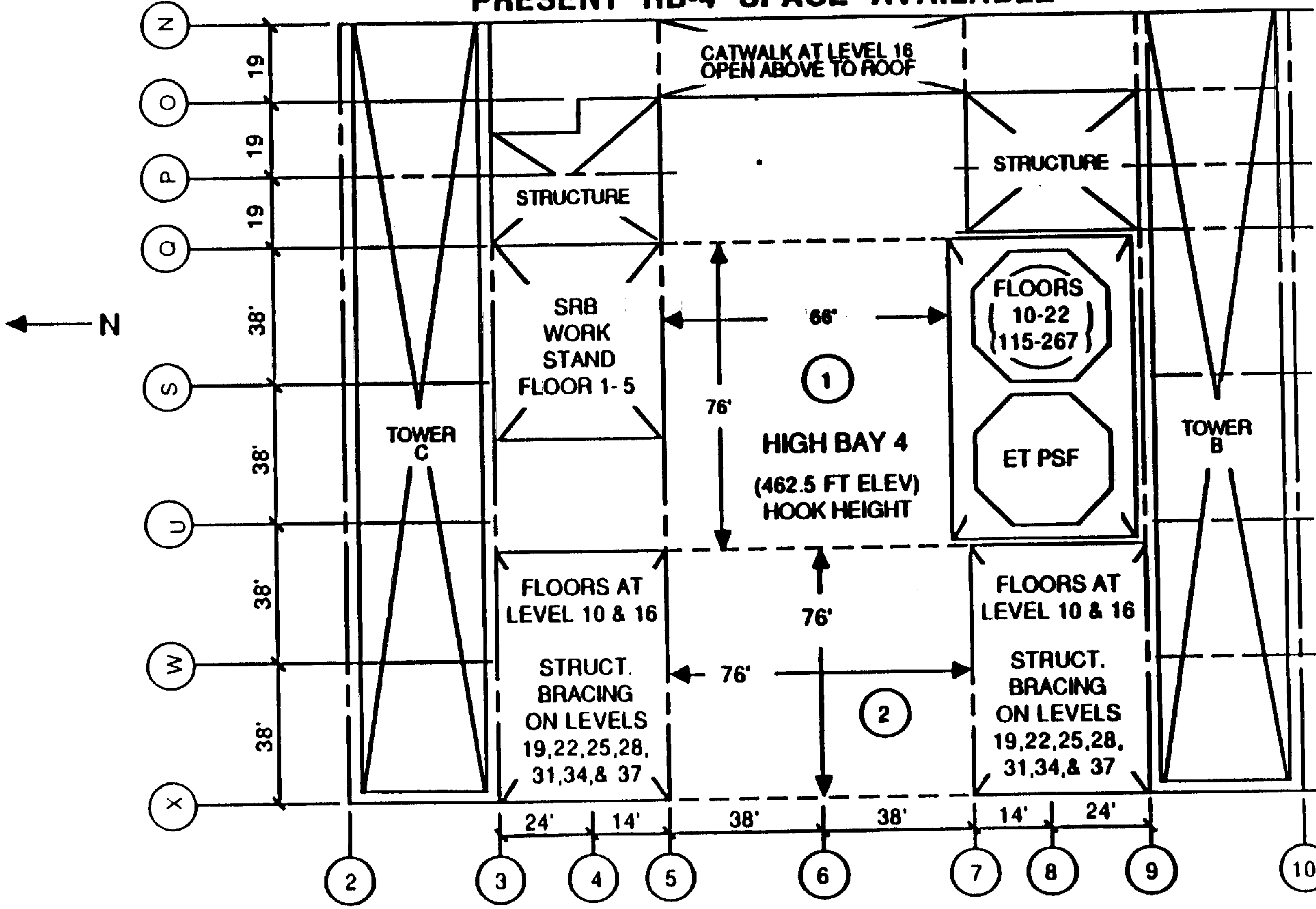
PRESENT HB-4 SPACE AVAILABLE



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CONCEPT FOR HI-BAY 4 SPACE UTILIZATION WITH TWO LRB CELLS

THE FOLLOWING LOCATION IS AVAILABLE:

- AREAS BETWEEN COLUMN LINES U, X, 5, 6 AND U, X, 6, 7 (IN FRONT OF HIGH BAY DOOR) ABOVE LEVEL 10.

THIS ARRANGEMENT OF CELLS WILL PERMIT STORAGE OF A LRB FLIGHT PAIR AND PROCESSING OF A FLIGHT PAIR.

HAVING THE CELLS ABOVE LEVEL 10 ELEVATION WILL ALLOW FOR VERTICAL ENGINE REMOVAL/INSTALLATION AND ACCESS TO THE HIGH BAY DOOR.

THE CAPABILITY TO PROVIDE BACK-UP TO THE RPSF REQUIRES MAINTAINING THE SRB WORK STANDS IN THE HB.

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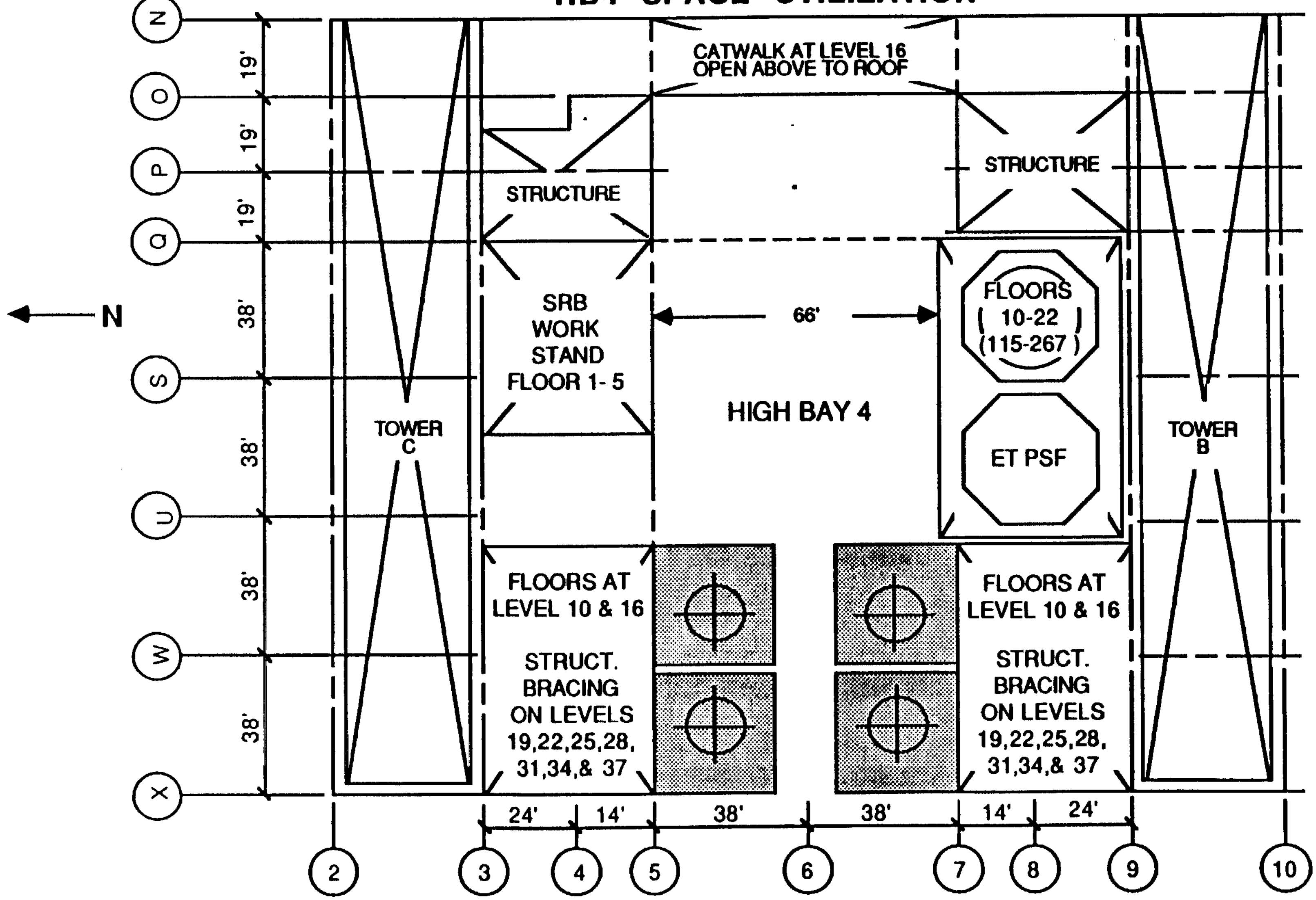
HB4 SPACE UTILIZATION



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TWO CONCEPTS FOR FLIGHT ELEMENT FLOW IN VAB

- CONCEPT 1- USING HB 2 & 4 FOR ET & LRB PROCESSING

- CONCEPT 2- USING NEW ET/LRB PROCESSING FACILITY

CONCEPT 1
FLIGHT ELEMENT FLOW PATH
VAB HB 1, 3 AS INTEGRATION CELLS
VAB HB 2, 4 AS ET/LRB C/O CELLS

THE FLOW PATH CONSISTS AS FOLLOWS:

- o SRB ARRIVE FROM RPSF AND LIFT OPERATION TO HB 1 OR 3
- o ORBITER ARRIVE FROM OPF AND LIFT OPERATIONS TO HB 1 OR 3
- o LRB RECEIVED FROM BARGE AND LIFTED TO HB 2 OR 4 FOR PROCESSING
  - FOR STACKING: LIFTING OPERATION FROM HB 2 TO 1 OR 4 TO 3.
  - IN HB 2 AND 4. THESE WILL BE LIFT OPERATIONS TO MOVE LRB FROM C/O TO STORAGE CELLS
- o ET RECEIVED FROM BARGE AND LIFTED TO HB 2 OR 4 FOR PROCESSING
  - FOR STACKING: LIFTING OPERATION FROM HB 2 TO 1 OR 4 TO 3
  - IN HB 2 AND 4. THESE WILL BE LIFT OPERATIONS TO MOVE ET FROM C/O TO STORAGE CELLS

THE SIGNIFICANT CONCERN AS THE NUMBER OF LIFT OPERATIONS, THE TIMELY ACTIVATION OF HB 3 AND 1 TO SUPPORT LRB AND SRB, AND ACTIVATION OF HB 4 AND 2 TO SUPPORT LRB PROCESSING.

THE ACTIVATION REQUIREMENTS FOR THIS PROCESS INCLUDES

- o ACTIVATION/MODIFICATION OF HB 1 AND 3 AS INTEGRATION CELLS TO SUPPORT LRB AND SRB
- o ACTIVATION/MODIFICATION OF HB 2 AND 4 AS LRB PROCESSING FACILITIES.

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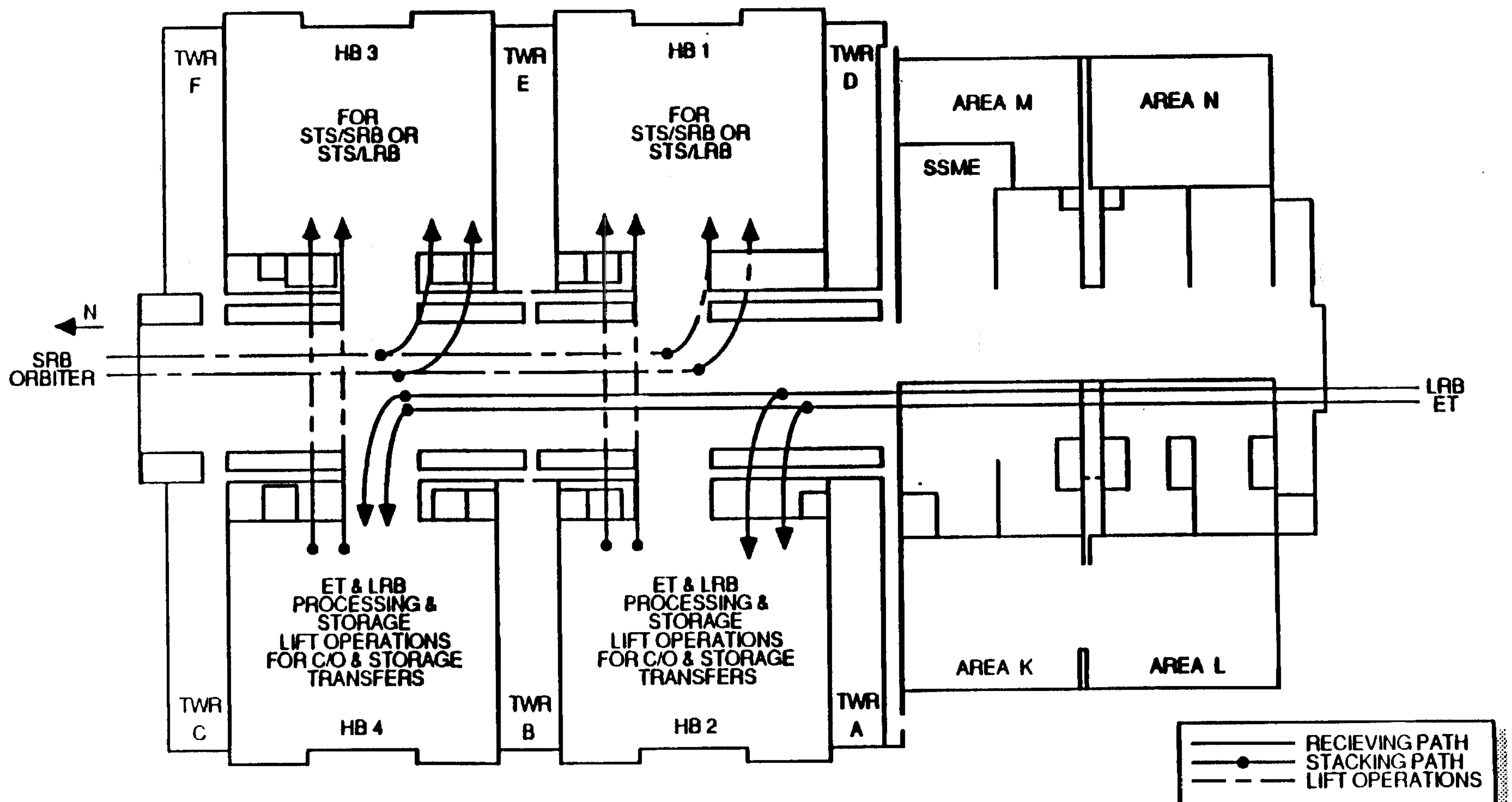
CONCEPT 1

FLIGHT ELEMENT FLOW PATH
VAB HIGH BAY 1, 3 AS INTEGRATION CELLS
HIGH BAY 2, 4 AS ET/LRB PROCESSING CELLS



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VAB FLOOR PLAN

C-9

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CONCEPT 2
FLIGHT ELEMENT FLOW PATH
VAB HB 1, 3, 4 AS INTEGRATION CELLS
ET PROCESSING AT HORIZONTAL FACILITY

THE FLOW PATH CONSISTS AS FOLLOWS:

- o SRB ARRIVES FROM RPSF AND LIFT OPERATION TO HB 1 OR 3
- o ORBITER ARRIVES FROM OPF AND LIFT OPERATION TO HB 1, 3 OR 4
- o LRB ARRIVES FROM LRB FACILITY AND LIFT OPERATION TO HB 3 OR 4
- o ET ARRIVES FROM HORIZONTAL FACILITY AND LIFT OPERATION TO HB 1, 3 OR 4

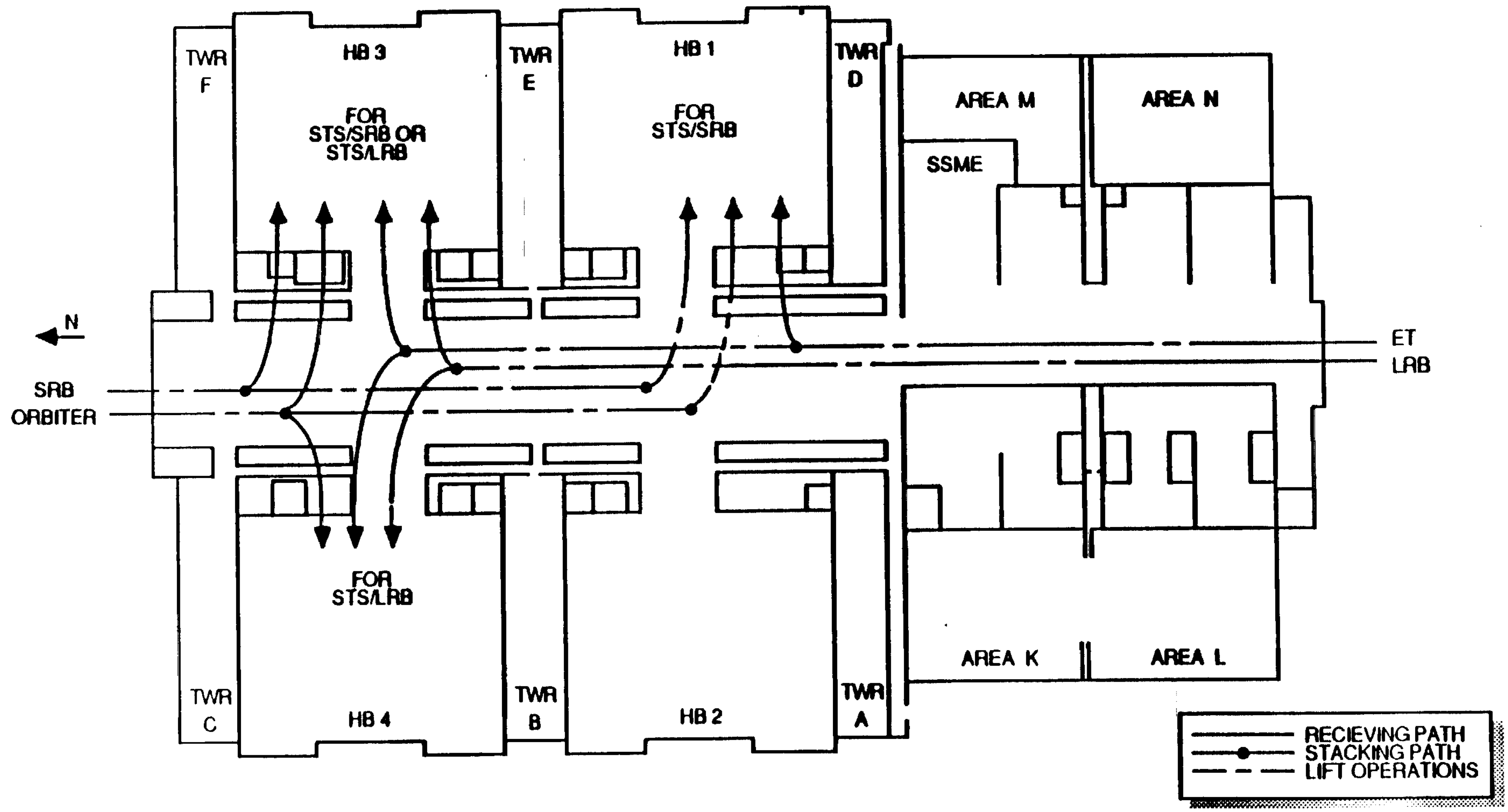
THIS FLOW PATH PROVIDES THE MINIMUM CRANE/LIFT OPERATIONS

THE ACTIVATION REQUIREMENTS FOR THIS PROCESS INCLUDES:

- o ACTIVATION OF AN OFF LINE LRB FACILITY
- o ACTIVATION OF OFF LINE ET FACILITY
- o ACTIVATION OF VAB HB 4 AS AN INTEGRATION CELL
- o MODIFICATION/ACTIVATION OF VAB HB 3 AS AN INTEGRATION CELL SUPPORTING LRB AND SRB
- o RELOCATION OF SRB STANDS FROM HB 4 TO HB 2

CONCEPT 2

FLIGHT ELEMENT FLOW PATH
VAB HIGH BAY 1, 3, 4 AS INTEGRATION CELLS
ET PROCESSING AT HORIZONTAL FACILITY



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VAB FLOOR PLAN

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VAB LIFT OPERATION SUMMARY

EXCLUDING THE ORBITER AND SRB LIFT REQUIREMENTS, THERE IS SIGNIFICANT REDUCTION IN THE NUMBER OF FLIGHT ELEMENT LIFTS WHEN ET's AND LRB's ARE PROCESSED HORIZONTALLY.

IF THE PLANNED USE OF THE VAB REMAINS AS IT IS TODAY UTILIZING HB 2 & 4 FOR ET AND LRB PROCESSING 10 LIFT OPERATIONS WOULD BE REQUIRED TO STACK AN LRB/STS. SRB/STS WOULD REMAIN UNCHANGED.

IF LRB/STS INTEGRATION OCCURRED IN HB 3 OR 4 AND ET's AND LRB's WHEN PROCESSED HORIZONTALLY ELSEWHERE 4 LIFT OPERATIONS WOULD BE REQUIRED TO STACK. SRB/STS LIFT OPERATIONS FOR HB 1 & 3 WOULD DECREASE BY 2.

SINCE LIFTING FLIGHT HARDWARE IS A HAZARDOUS OPERATION REDUCING THE LIFT OPERATIONS REPRESENTS A SIGNIFICANT ENHANCEMENT TO GROUND OPERATIONS SAFETY.

VAB LIFT OPERATIONS SUMMARY

	LIFTS PER FLIGHT SET			TOTAL
	BOOSTER	ET	ORB	
CURRENT SRB/STS	10	3	1	14
CONCEPT 1 LRB/STS	6	3	1	10
CONCEPT 2 LRB/STS	2	1	1	4

ACTIVATION SCHEDULE

THE SIGNIFICANT IMPACT OF PROCESSING LRB's IN THE VAB TO MEET A 1/96 LAUNCH DATE WILL BY THE NEED TO CONVERT VAB HB 3 FROM SRB ONLY TO LRB AND SRB CAPABILITY. OPEN WORK TIMES TO MAKE THE CONVERSION WILL NOT ALLOW THE TIMELY COMPLETION. THE ESTIMATE CONVERSION TIME IS 13 MONTHS WITHOUT INTERRUPTION. THERE ARE APPROX. 151 WORKDAYS BETWEEN OCT. 1991 TO OCT 1994 AVAILABLE.

THE USE OF HB 4 AS AN INTEGRATION CELL PREVENTS THE LOSS OF FLIGHTS SINCE CONVERSION OF HB 3 CAN BE DELAYED UNTIL LRB FLIGHTS HAVE COMMENCED AND SRB FLIGHTS ARE REDUCED. THIS HOWEVER WILL REQUIRE HB 2 TO SUPPORT TWICE AS MANY ET's WITH LITTLE ROOM FOR LRB.

THE OPTIMUM ACTIVATION SCHEDULE IS ALLOWED BY MOVING ET's TO A NEW FACILITY.

LIQUID ROCKET BOOSTER INTEGRATION SECOND PROGRESS REVIEW

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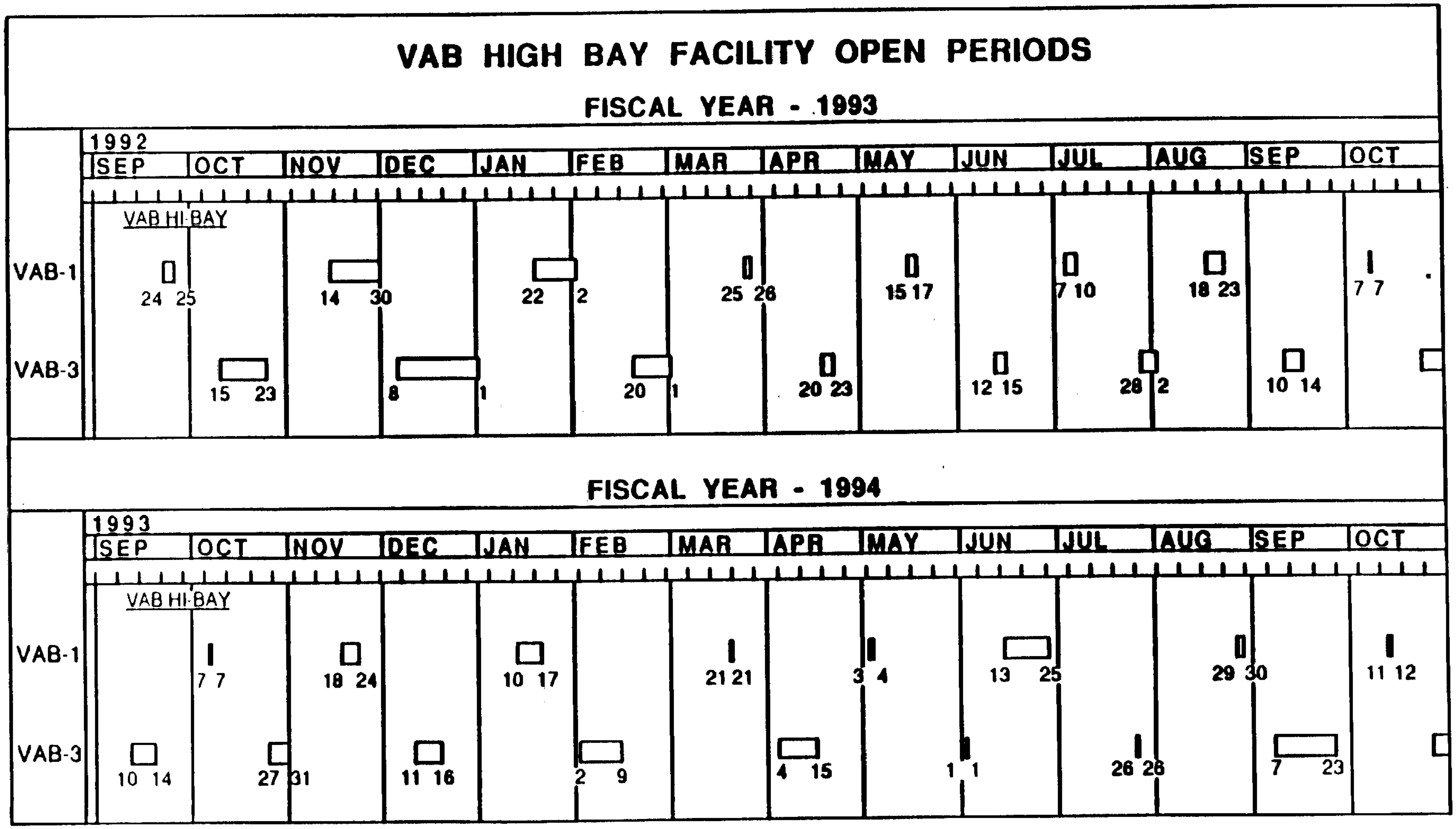

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ACTIVATION OF FIRST LINE FACILITIES

USING HB 3 FOR FIRST LRB STACKING AND HB 4 FOR FIRST LRB PROCESSING (CONCEPT 1) WILL REQUIRE SUSPENSION OF 5 - 7 SRB/SSV FLIGHTS DURING THE HB 3 MODIFICATION PERIOD. THE MODIFICATION IS ESTIMATED TO BE 13 MONTHS OF UNINTERRUPTED TIME BETWEEN THE CONCEPTUAL TIME FRAME OF OCTOBER 1993 TO OCTOBER 1994. THE AREA CONTROLS IN THE VAB DURING THE MODIFICATION OF HB 3 & HB 4 WILL BE EXTENSIVE DUE TO CONSTRUCTION AND SSV INTEGRATION (LIFTING, SRB STACKING) OCCURRING IN PARALLEL.

(USING THE HB 4 FOR FIRST LRB STACKING AND A NEW HPF FOR ET & LRB (CONCEPT 2) WILL NOT REQUIRE SUSPENSION OF SRB/SSV FLIGHTS. THE NEW HPF FOR ET CAN BE ACTIVATED PRIOR TO HB 4 MODIFICATION AND STACKING. MODIFICATION OF HB 3 AS A DUAL INTEGRATION FACILITY FOR SRB/SSV A LRB/SSV CAN OCCUR AFTER THE SRB FLIGHT RATE IS DOWN TO 7 PER YEAR.

ACTIVATION OF FIRST LINE FACILITIES

CONCEPT 1

- SUSPENSION OF 5 - 7 SRB / SSV FLIGHTS
- EXTENSION AREA CONTROL DURING MODIFICATION PERIOD

CONCEPT 2

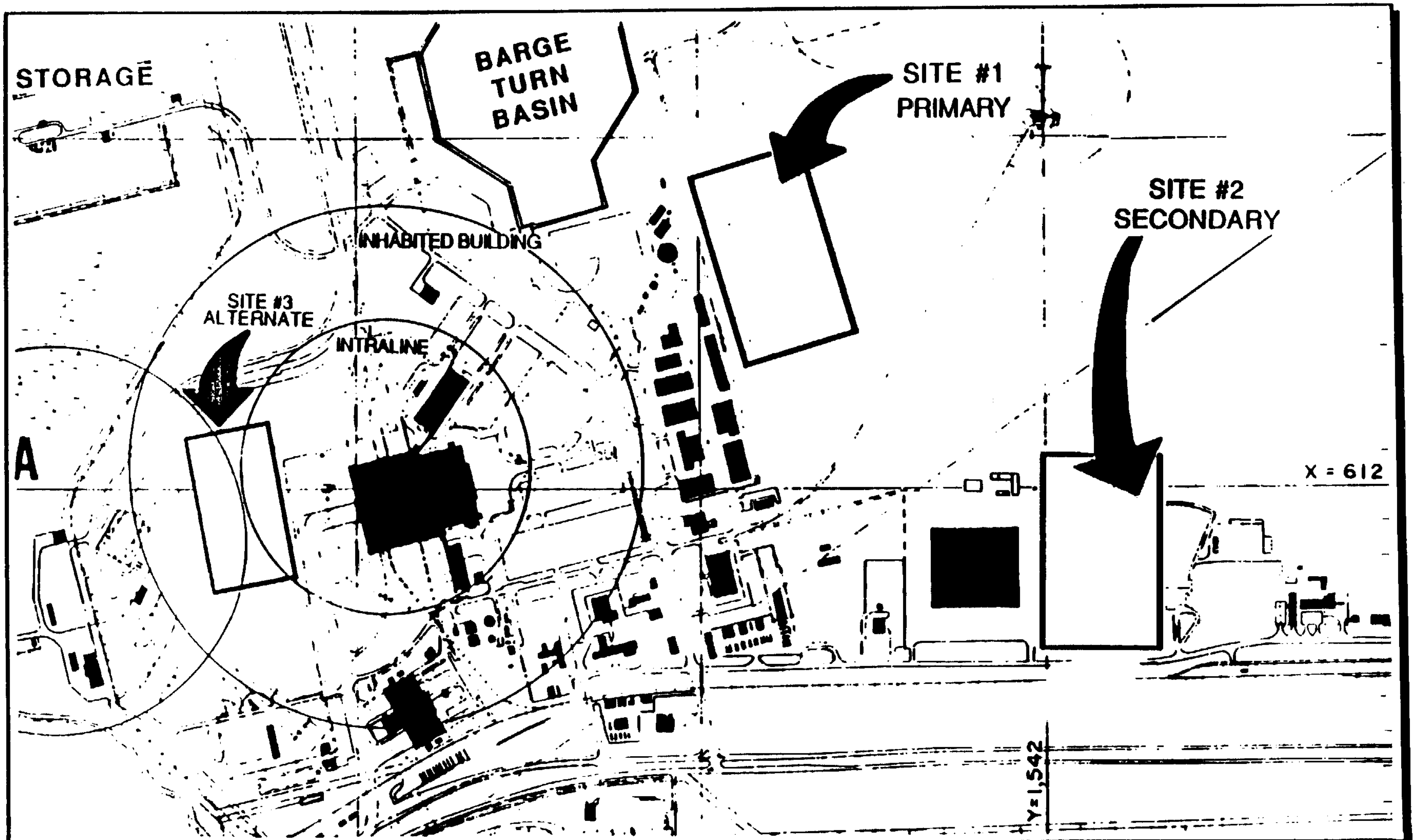
- NO IMPACT TO SRB /SSV FLIGHTS
- ACTIVATE HB-3 WHEN SRB / SSV FLIGHT DOWN TO 7 PER YEAR
- MINIMIZE AREA CONTROLS DURING MODIFICATION PERIOD

ET/LRB HORIZONTAL PROCESSING FACILITY SITE LOCATION

THIS PROPOSED SITE PROVIDES AN EXCELLENT POTENTIAL LOCATION. THE EXISTING PRESS SITE MAY BE RELOCATED WHICH WILL PROVIDE ADDITIONAL AREA. IT IS IN CLOSE PROXIMITY TO THE BARGE TERMINAL & TOW ROUTE. SAFETY CONCERNS ARE ELIMINATED SINCE THIS SITE IS BEYOND THE VAB QUANTITY-DISTANCE (QD) ENVIRONMENTAL CONCERNS ARE MINIMIZE SINCE AN EXISTING LOCATION IS BEING UTILIZED.

THIS SITE WAS ONE OF THE TWO PRIME CANDIDATE SITES PRESENTED AT THE FIRST PROGRESS REVIEW.

ET/LRB PROCESSING FACILITY-SITING PLAN



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ET/LRB DESIGN REQUIREMENTS FOR STORAGE AND PROCESSING OPERATIONS WITH SRB STANDS IN VAB

COMPARISON

LRB	CONCEPT 1	CONCEPT 2
LIFT/ROTATION	YES	NO
STORAGE/PROCESSING	VERTICAL ON HOLDDOWN	HORIZ (ON TRANSPORTER)
ENGINE CHANGEOUT	VERTICAL	HORIZ (ON TRANSPORTER)
ENVELOPE	38' X 76'	UNLIMITED

ET		
LIFTING/ROTATION	YES	NO
STORAGE/PROCESSING	VERTICAL	HORIZ (ON TRANSPORTER)
ENVELOPE	EXISTING	UNLIMITED

CONCEPT 1 EVALUATION

USING THE VAB HB 2 & 4 FOR LRB/ET PROCESSING/STORAGE. HAS CONSTRAINTS TO ACTIVATION AND PROCESSING.

ACTIVATION OF HB 1 & 3 TO SUPPORT LRB AS WELL AS SRB WILL REQUIRE AN UNINTERRUPTED OUTAGE OF 13 MONTHS. THIS WILL RESULT IN A SUSPENSION OF FLIGHTS. ACTIVATION OF HB 2 & 4 FOR LRB PROCESSING/STORAGE WILL IMPACT ET PROCESSING OR ET PROCESSING AND SRB STACKING WILL INTERRUPT ACTIVATION. ACTIVATION WILL BE REQUIRED TO BE COVERED BY THE INTEGRATED AREA CONTROL SCHEDULE.

PROCESSING CONSTRAINTS INCLUDE THE NEED TO PROCESS THE LRB VERTICALLY AND WILL INCREASE THE NUMBER OF CRANE LIFT OPERATIONS IN THE VAB. PROCESSING IN THE VAB WILL BE COMPLICATED BY THE NUMEROUS CRANE OPERATIONS AND AREA CONTROL SCHEDULES FOR SRB, LRB, ET AND ORBITER PROCESSING AND HAZARDOUS OPERATIONS. THE SURGE/STORAGE CAPACITY WILL BE LIMITED. CONTINGENCY USE OF THE SRB WORK STANDS FURTHER COMPLICATE THE JOINT OCCUPANCY OF VAB HB 4. FUTURE USE OF THE VAB FOR ELEMENT STORAGE (ORBITER, PAYLOAD CANISTER) OR FUTURE PROGRAMS (ALS, SHUTTLE C) WILL BE ELIMINATED.

CONCEPT 1 EVALUATION

- ACTIVATION IN VAB WILL IMPACT ON-GOING OPS
- PROCESSING IN VAB COMPLICATED BY NUMEROUS LIFTS/AREA CONTROL/SCHEDULE INTERACTION
- FUTURE USE OF VAB LIMITED

CONCLUSION

BY THE IMPLEMENTATION OF CONCEPT 2, WHICH INCLUDES A NEW LRB/ET HORIZONTAL PROCESSING/STORAGE FACILITY AND ACTIVATION OF VAB HB 4 AS LRB INTEGRATION FACILITY MANY OF THE CONSTRAINTS ARE ELIMINATED.

ACTIVATION OF HB 4 WILL ELIMINATE THE NEED TO SUSPEND SCHEDULED FLIGHT TO BE INTEGRATED IN HB 3. CONVERSION OF HB 3 AS A LRB/SRB INTEGRATION FACILITY CAN BE DEFERRED UNTIL SRB LAUNCHES ARE BELOW SEVEN AND CAPABLE OF BEING SUPPORTED BY HB 1.

THE NUMBER OF CRANE/LIFT OPERATIONS TO PROCESS ET/LRB ELEMENTS IS REDUCED. LOCATING THE LRB PROCESSING IN A SEPARATE FACILITY PLACES THE PERSONNEL AND FLIGHT ELEMENTS OUTSIDE THE QUANTITY/DISTANCE INHABITED SAFETY ZONE OF THE VAB.

A NEW PROCESSING FACILITY FOR LRB & ET MINIMIZES AREA CONTROL SCHEDULE IMPACTS FOR THE VAB.

CONCLUSION

IMPLEMENTATION OF CONCEPT 2 WILL:

- MINIMIZE LIFT OPS
- ELIMINATE THE REQUIREMENT OF SUSPEND LAUNCHES
- PROVIDES REMOTE ET/LRB PROCESSING/STORAGE
- MINIMIZE AREA CONTROL, SCHEDULING INTERACTIONS

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LIQUID ROCKET BOOSTER INTEGRATION SECOND PROGRESS REVIEW

OCT 1988

AGENDA

I. INTRODUCTION	Gordon Artley
II. STUDY PROGRESS	
A. ACHIEVEMENT SUMMARY	Pat Scott
B. ENGINE PROCESSING STUDY	Glen Waldrop
C. LRB/ET PROCESSING EVALUATION	Greg DeBlasio
D. SAFETY & ENVIRONMENTAL IMPLICATIONS	Roger Lee
E. GOCM STATUS	Stephen Schneider
III. SUMMARY	Gordon Artley

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SAFETY/ENVIRONMENTAL IMPLICATIONS

STUDY OBJECTIVES:

- IDENTIFY SAFETY AND ENVIRONMENTAL IMPLICATIONS FOR LRB INTEGRATION INTO CURRENT BASELINE
- ANALYZE SAFETY/ENVIRONMENTAL IMPLICATIONS - GENERIC AND STATION SET UNIQUE
- EVALUATE LRB VS SRB PROCESSING AND IDENTIFY ENHANCEMENTS
- DEVELOP CONCLUSIONS AND RECOMMENDATIONS BASED ON STUDY FINDINGS
- DOCUMENT FINDINGS IN FINAL REPORT

SAFETY/ENVIRONMENTAL IMPLICATIONS

INITIAL PITCH PRESENTED IN JANUARY 1988 ADDRESSED SAFETY/ENVIRONMENTAL IMPLICATIONS OF HYPERGOLS (MMH/N2O4). SUBSEQUENTLY HYPERGOLS WERE DROPPED FROM CONSIDERATION AS PROPELLANTS FOR THE LRB.

SAFETY/ENVIRONMENTAL IMPLICATIONS BEING ADDRESSED IN THE STUDY WERE PRESENTED AT THE FIRST PROGRESS REVIEW PRESENTED IN JULY 1988; UPDATE PRESENTED IN AUGUST 1988 REVIEW.

GENERIC AND UNIQUE SAFETY IMPLICATIONS, AS WELL AS ENVIRONMENTAL IMPLICATIONS WERE ADDRESSED AND COMPILED IN A DRAFT REPORT SUBMITTED FOR INTERNAL LSOC REVIEW IN AUGUST 1988 WHICH ASSUMED RP-1/LO2 WERE PRIMARY LRB PROPELLANTS WITH LH2/LO2 AND CH-4/LO2 AS ALTERNATES. A CURSORY LOOK WAS TAKEN AT THE ALTERNATE PROPELLANTS AND IT WAS RECOMMENDED THAT CH-4/LO2 BE DROPPED FROM CONSIDERATION AS LRB PROPELLANTS DUE TO SAFETY IMPLICATIONS AND LACK OF EXPERIENCE WITH THIS TYPE PROPELLANT. IF CH-4/LO2 IS SELECTED AS A PRIMARY PROPELLANT A MORE IN- DEPTH ANALYSIS OF THE SAFETY/ENVIRONMENTAL IMPLICATIONS SHOULD BE PERFORMED.

COMMENTS AND REDLINES FROM INTERNAL LSOC REVIEW OF DRAFT REPORT RECEIVED SEPT. 1988. REPORT CURRENTLY BEING REVISED TO INCORPORATE REDLINES AND CHANGES. RESUBMISSION OF REPORT FOR FINAL INTERNAL LSOC REVIEW IS SCHEDULED IN MID-OCT. 1988 AND FINAL REPORT SUBMISSION IN MID-NOV. 1988.

THIS PRESENTATION WILL ADDRESS THE MAJOR SAFETY AND ENVIRONMENTAL IMPLICATIONS IDENTIFIED IN THE STUDY TO DATE.

SAFETY AND ENVIRONMENTAL IMPLICATIONS

MAJOR ISSUES/STATUS

- EVALUATION OF HYPERGOLS AS PRIMARY LRB PROPELLANTS
- SUMMARY OF PROPELLANT AND SAFETY ISSUES BEING ADDRESSED IN THE BOOSTER STUDY
- DRAFT REPORT SUBMITTED AUG. 1988 FOR INTERNAL LSOC REVIEW
- UPDATES ARE IN PROGRESS. RESUBMISSION OF REPORT FOR FINAL REVIEW DRAFT MID OCT 1988 AND SUBMISSION OF FINAL REPORT MID NOV 1988
- MAJOR SAFETY AND ENVIROMMENTAL IMPLICATIONS ARE SUMMARIZED IN THIS PRESENTATION

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OPERATIONAL SAFETY ADVANTAGES OF LRB

1. NO HANDLING OF LIVE PROPELLANTS DURING PROCESSING OPERATIONS
2. DECREASE IN HAZARDOUS CONTROL ZONES IN THE VAB
3. QUANTITY - DISTANCE REQUIREMENTS IN VAB AND RPSF DRASTICALLY REDUCED OR ELIMINATED
4. SRB STACKING OPERATIONS ELIMINATED - REDUCING LIFTING HAZARDS
5. REDUCES OR ELIMINATES WORKING UNDER SUSPENDED LOADS
6. NO LOWERING OF PERSONNEL INTO LIVE SEGMENTS
7. NO APU / HYPER BOOSTER OPERATIONS

MAJOR SAFETY IMPLICATIONS

QUANTITY DISTANCE REQUIREMENTS PREVIOUSLY ESTABLISHED FOR THE VAB, RPSF AND OPF (INTRALINE AND INHABITED BUILDING DISTANCES) DURING SRB AND ORBITER PROCESSING WERE TAKEN INTO CONSIDERATION WHEN SITING LOCATIONS FOR THE LRB/ET PROCESSING FACILITY.

THREE PROPOSED SITES WERE SELECTED AS SHOWN IN THE LRB/ET PROCESSING FACILITY SITING PLAN. SITE #1 (PRIMARY) IS IN THE GENERAL AREA OF THE EXISTING PRESS SITE. SITE #2 IS SOUTH OF THE LOGISTICS FACILITY. BOTH SITES ARE OUTSIDE THE QUANTITY DISTANCE REQUIREMENTS CURRENTLY ESTABLISHED. EVEN THOUGH THESE REQUIREMENTS ARE NOT BEING STRICTLY ENFORCED, WE DECIDED NOT TO INFRINGE ON THESE ZONES BY LOCATING THE FACILITY WITHIN IT. OTHER FACTORS WERE CONSIDERED IN THE SITE SELECTION WHICH WILL BE DISCUSSED IN THE ENVIRONMENTAL IMPLICATIONS.

QUANTITY DISTANCE REQUIREMENTS FOR SITING STORAGE FACILITIES AT THE PAD ARE BASED ON REQUIREMENTS CALLED OUT IN AFR 127-100, EXPLOSIVE SAFETY STANDARD. THE DISTANCES SHOWN ON THE SITE PLAN ARE FOR THE PROJECTED MAXIMUM STORAGE CAPABILITIES FOR SUPPORT OF THE LRB. THE DISTANCES WERE ESTABLISHED FOR LO2 (17,100,000 LBS), RP-1 (1,734,000 LBS), AND LH2 (1,062,000 LBS). SITING CAN BE ACCOMPLISHED WITHOUT IMPLICATING EXISTING FACILITIES.

MAJOR SAFETY IMPLICATIONS

- QUANTITY DISTANCE REQUIREMENTS
  - SITING OF ET/LRB PROCESSING FACILITY
    - PRESS SITE (PRIMARY SITE)
    - N.E. OF VAB
    - SOUTH OF LOGISTICS FACILITY
  - SITING OF STORAGE FACILITES AT THE PADS

MAJOR SAFETY IMPLICATIONS (CONTINUED)

QUANTITY DISTANCE REQUIREMENTS FOR THE VAB AS SHOWN ON THE ET/LRB PROCESSING FACILITY SITING PLAN AS FOLLOWS:

INTRALINE DISTANCE = 820 FT.

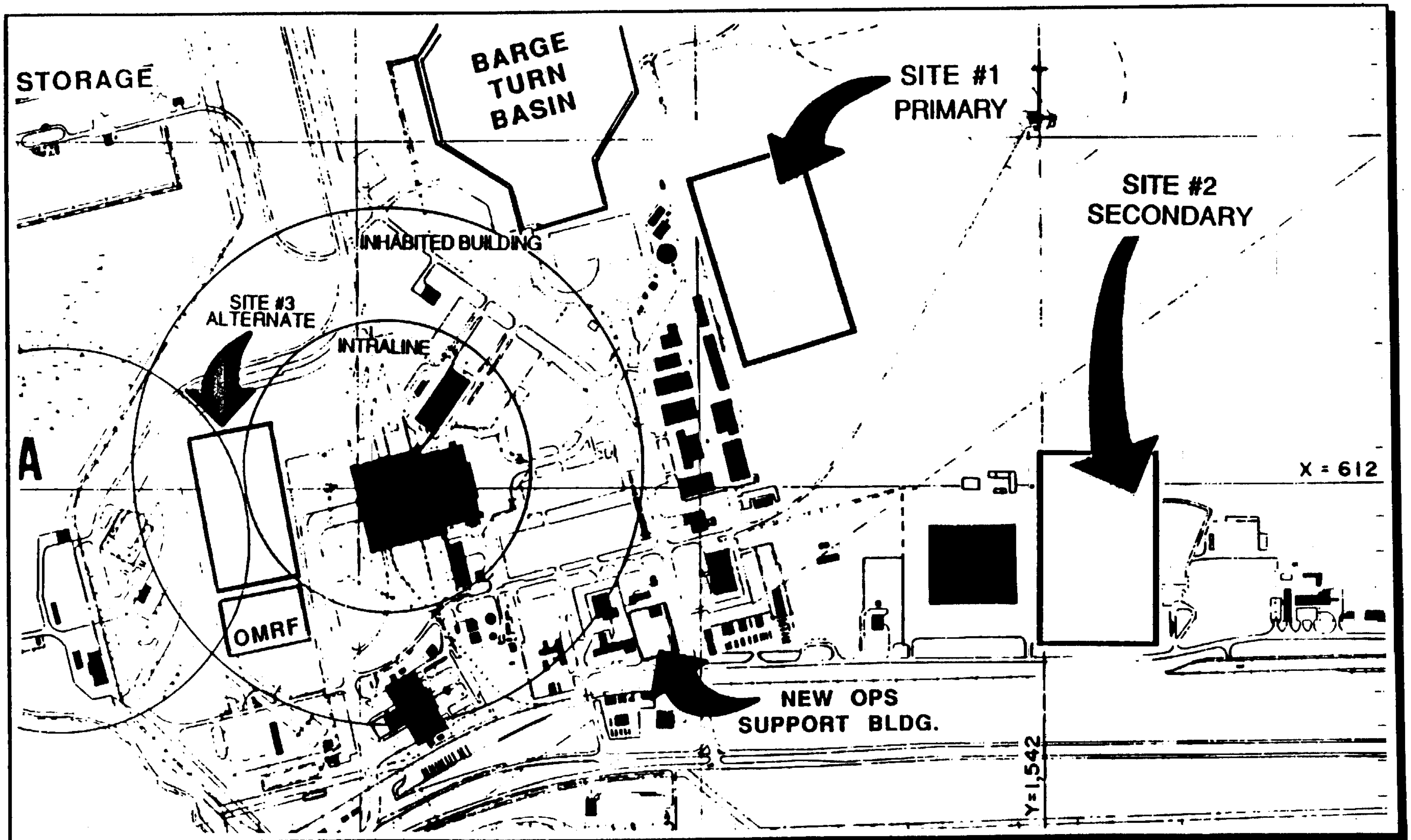
THIS IS THE MINIMUM DISTANCE REQUIRED FOR SEPARATION OF STRUCTURES HOUSING NONEXPLOSIVE OPERATIONS FROM EXPLOSIVE OPERATING BUILDING.

INHABITED BUILDING DISTANCE = 1,320 FT

THIS IS THE MINIMUM ALLOWABLE DISTANCE BETWEEN INHABITED BUILDINGS (STRUCTURES NOT DIRECTLY RELATED TO EXPLOSIVE OPERATIONS WHERE PEOPLE USUALLY ASSEMBLE TO WORK) AND AN EXPLOSIVE LOCATION.

AS CAN BE SEEN FROM THE SITE PLAN, THE PROPOSED SITE NORTHEAST OF THE VAB INFRINGES UPON THE INHABITED BUILDING AND INTRALINE QUANTITY DISTANCE REQUIREMENTS.

ET/LRB PROCESSING FACILITY-SITING PLAN



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MAJOR SAFETY IMPLICATIONS (CONTINUED)

THE QUANTITY DISTANCES SHOWN ON THE PAD A SITE PLAN FOR LRB PROPELLANTS REPRESENT MAXIMUM STORAGE CAPACITY. THE SMALLER INNER CIRCLE REPRESENTS THE INTRAGROUP/INTRALINE QUANTITY DISTANCE REQUIREMENT AND THE LARGER OUTER CIRCLE REPRESENTS EITHER THE INHABITED BUILDING QUANTITY DISTANCE REQUIREMENT FOR THE LO2 SITE OR THE PROTECTED DISTANCE REQUIREMENT FOR LH2. THE INHABITED BUILDING QUANTITY DISTANCE REQUIREMENT FOR RP-1 FALLS WITHIN THE PROTECTED DISTANCE REQUIREMENT FOR LH2 AND SINCE THEY ARE IN THE SAME COMPATIBILITY GROUP (LIQ-C) IT DOES NOT APPLY. LISTED BELOW ARE THE QUANTITY DISTANCE REQUIREMENTS FOR EXISTING, AS WELL AS, THOSE PROJECTED FOR LRB PROPELLANT REQUIREMENTS, PER AFR 127-100, EXPLOSION SAFETY STANDARD.

	UNPROTECTED DISTANCE	PROTECTED DISTANCE	INTRALINE DISTANCE
EXISTING LH2 TANK	* 1,800 FT	500 FT	185 FT
ADDITIONAL LH2 TANK	* 1,800 FT	630 FT	235 FT

* NOT SHOWN ON SITE PLAN

NOTE: LH2 IS CLASSIFIED AS A HAZARD GROUP III LIQUID PROPELLANT AND COMPATIBILITY STORAGE GROUP LIQUID C BY AFR 127-100. PROTECTED AND UNPROTECTED DISTANCES APPLY ONLY TO THIS GROUP.

	INTRAGROUP/INTRALINE DISTANCE	INHABITED BUILDING STRUCTURE
RP-1 EXISTING AND PROJECTED	175 FT	235 FT
EXISTING LO2 TANK	305 FT	235 FT
ADDITIONAL LO2 TANK	* 350 FT	* 700 FT

* DISTANCES DETERMINED BY COMBINING TOTAL QUANTITIES FOR EXISTING AND ADDITIONAL LO2 AND EXTRAPOLATING FROM DATA IN AFR 127-100.

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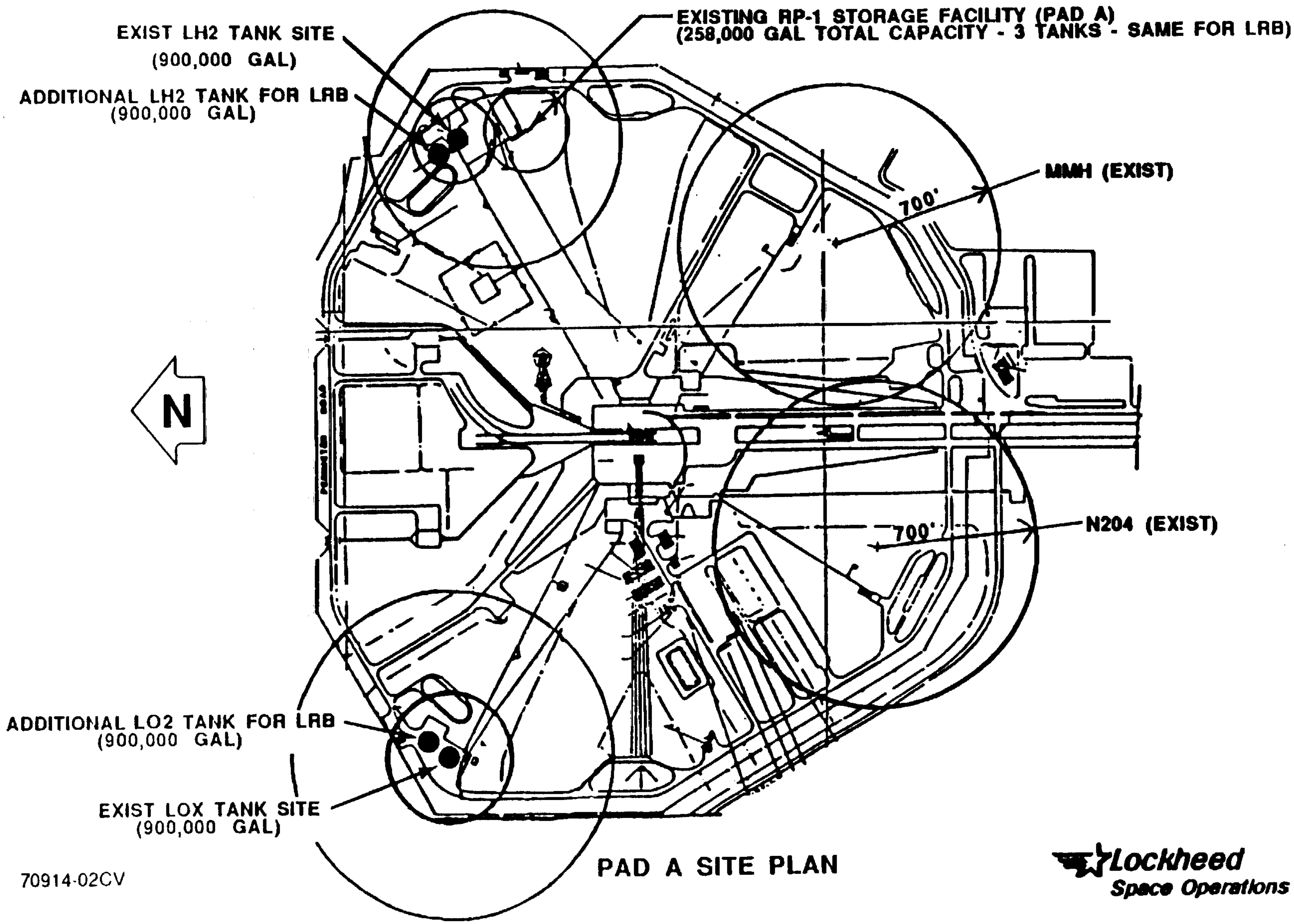
MAJOR SAFETY IMPACTS (CONT)
QUANTITY DISTANCE LRB PROPELLANT STORAGE SITES



PAD A SITE PLAN

MAJOR SAFETY IMPLICATIONS (CONTINUED)

RP-1 IS CLASSED AS A COMBUSTIBLE LIQUID BY NFPA FLAMMABLE AND COMBUSTIBLE LIQUIDS CODES, CHAPTER 30, AND THE STORAGE/SERVICING FACILITY MUST MEET DESIGN, CONSTRUCTION, OPERATION AND MONITORING REQUIREMENTS SPECIFICATIONS AS CALLED OUT IN NFPA CODES, UNDERWRITERS LABORATORIES, INC. STANDARDS, AMERICAN PETROLEUM INSTITUTE STANDARDS AND SPECIFICATIONS, AND THE AMERICAN SOCIETY FOR TESTING AND MATERIALS STANDARDS.

RP-1 STORAGE FACILITY EXISTING AT PAD A USED DURING APOLLO PROGRAM. CONDITION OF STORAGE CONTAINERS AND PIPING UNKNOWN. NDE SHOULD BE PERFORMED TO DETERMINE CONDITION OF SYSTEM AND IF IT MEETS CURRENT REQUIREMENTS AS LISTED ABOVE. OTHERWISE NEW FACILITY WILL BE REQUIRED.

RP-1 STORAGE FACILITY WAS REMOVED FROM PAD B AND THEREFORE WILL REQUIRE NEW FACILITY.

A SUGGESTION HAS BEEN MADE TO CONSIDER A CENTRALIZED STORAGE FACILITY TO SERVICE BOTH PADS.

REGARDLESS OF THE SELECTED OPTION, THE REQUIREMENTS FOR CONSTRUCTION MATERIAL, VENTING, LEAK DETECTION, FIRE PROTECTION, VAPOR DETECTION, AND SAFETY HANDLING PRACTICES MUST BE MET.

MAJOR SAFETY IMPLICATIONS (CONT)

- RP-1 STORAGE FACILITY
  - REFURBISHMENT OF PAD A FACILITY OR TOTALLY NEW FACILITY
  - TOTALLY NEW FACILITY REQUIRED AT PAD B
  - SUGGESTION TO CONSIDER NEW CENTRALIZED FACILITY
  - FACILITY OR FACILITIES MUST COMPLY WITH CURRENT SAFETY REQUIREMENTS

MAJOR SAFETY IMPLICATIONS (CONTINUED)

ACCORDING TO GP-1098, THE KSC STS GROUND SAFETY PLAN, THERE ARE 65 CONTROL ZONES ESTABLISHED FOR CURRENT HAZARDOUS OPERATIONS IN THE VAB, 21 OF WHICH COULD IMPACT CONSTRUCTION ACTIVITIES REQUIRED TO MODIFY HIGH BAY 4 FOR LRB PROCESSING.

THESE SAME CONTROL ZONES WOULD AFFECT LRB PROCESSING IN THE VAB DURING PHASE-IN WHEN SIMULTANEOUS LRB AND SRB PROCESSING OCCUR.

ACCORDING TO GP-1098, THERE ARE 61 CONTROL ZONES ESTABLISHED FOR CURRENT HAZARDOUS OPERATIONS AT THE PADS, MANY OF WHICH COULD IMPACT CONSTRUCTION ACTIVITIES REQUIRED TO MODIFY THE PADS FOR LRB SUPPORT. IN ADDITION, MANY OF THESE SAME CONTROL ZONES WILL IMPACT LRB PROCESSING ACTIVITIES DURING PHASE-IN. HOWEVER, THESE CAN BE MINIMIZED BY ADVANCED PLANNING AND SCHEDULING.

OUR FINAL REPORT EVALUATES THE CONTROL ZONES AT THE VAB AND PADS AND THEIR EFFECTS ON LRB PROCESSING TASK.

MAJOR SAFETY IMPLICATIONS

CONTROL ZONES FOR HAZARDOUS OPERATIONS

VAB:

- CONSTRUCTION ACTIVITIES TO MODIFY HIGH BAY 4
- SIMULTANEOUS LRB AND SRB OPERATIONS DURING LRB PHASE-IN

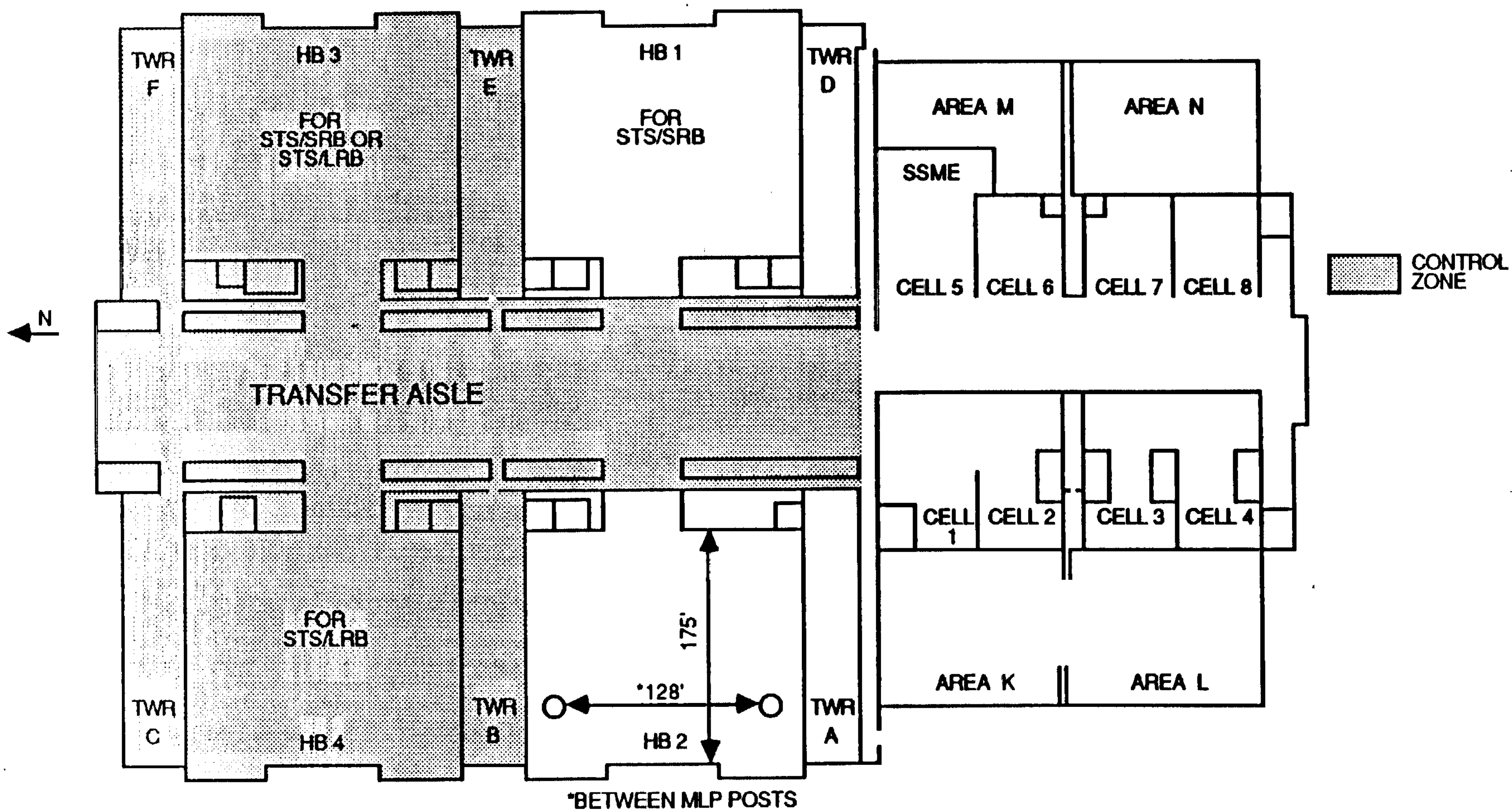
PADS:

- CONSTRUCTION ACTIVITIES TO MODIFY PADS FOR LRB SUPPORT
- LRB PROCESSING ACTIVITIES DURING PHASE-IN

MAJOR SAFETY IMPLICATION (CONTINUED)

THE CONTROL ZONE SHOWN ON THE VAB FLOOR PLAN IS JUST ONE EXAMPLE OF A CONTROL ZONE ESTABLISHED FOR HAZARDOUS OPERATIONS IN THE VAB. THIS CONTROL ZONE IS ESTABLISHED FOR SRM HOISTING AND STACKING OPERATIONS IN HB 3. FOR THESE OPERATIONS THE ENTIRE TRANSFER AISLE BETWEEN TOWERS A/D AND C/F, HIGH BAYS 3 AND 4, AND TOWERS B, C, F, AND E REQUIRE CLEARING OF ALL NON-ESSENTIAL PERSONNEL.

MAJOR SAFETY IMPLICATIONS (CONT)
CONTROL ZONE FOR SRM HOISTING AND STACKING OPERATIONS



VAB FLOOR PLAN

MAJOR SAFETY IMPLICATIONS (CONTINUED)

SINCE THE LRB/ET PROCESSING FACILITY IS A NEW FACILITY THERE ARE NUMEROUS SAFETY REQUIREMENTS TO CONTEND WITH DURING DESIGN, CONSTRUCTION AND OPERATION PHASES, SUCH AS: (1) FIRE DETECTION/PROTECTION SYSTEMS; (2) CONSTRUCTION TO MEET FIRE RATINGS IN HAZARD CLASSIFIED AREAS; (3) O2 AND ENVIRONMENTAL MONITORING FOR HAZARDOUS VAPORS; (4) VENTILATION SYSTEMS TO MEET INDUSTRIAL HYGIENE REQUIREMENTS; (5) HAZARD/EXPLOSION PROOF ELECTRICAL EQUIPMENT IN HAZARD CLASSIFIED AREAS; (6) LIGHTING TO MEET INDUSTRIAL HYGIENE REQUIREMENTS IN DIFFERENT WORK AREAS. WE PLAN TO USE OMRF LESSONS LEARNED:

DELIVERY OF THE QUANTITIES OF RP-1 REQUIRED TO SUPPORT AN LRB LAUNCH POSES SAFETY, AS WELL AS ENVIRONMENTAL CONCERNS (WHICH WILL BE DISCUSSED LATER). FROM A SAFETY STANDPOINT IT IS RECOMMENDED THAT ALL DELIVERY BE MADE BY RAIL CAR RATHER THAN TANKER TRUCK. THIS REDUCES THE POTENTIAL FOR ACCIDENTS BY CUTTING DOWN ON THE DELIVERY TRAFFIC AND PRESENTS LESS IMPLICATION ON PAD OPERATIONS.

MAJOR SAFETY IMPLICATIONS (CONT)

- LRB/ET PROCESSING FACILITY
  - MANY SAFETY REQUIREMENTS TO CONTEND WITH DURING DESIGN, CONSTRUCTION AND OPERATION PHASES
- RP-1 DELIVERY TO SITE STORAGE FACILITIES
  - RAIL DELIVERY VS TANKER TRUCK DELIVERY

MAJOR ENVIRONMENTAL IMPLICATIONS

ENVIRONMENTAL REGULATIONS ARE BECOMING INCREASINGLY MORE STRINGENT WHEN APPLED TO STORAGE OF HAZARDOUS MATERIALS (RP-1) IN STORAGE CONTAINERS. THEY IMPOSE STRICT REQUIREMENTS FOR LEAK DETECTION, NOT ONLY FOR THE STORAGE CONTAINER, BUT THE PIPING AS WELL. SPILL CONTAINMENT REQUIRES CAPABILITY TO CONTAIN THE TOTAL CAPACITY OF THE FUEL STORAGE FACILITY, SUCH AS THE METHOD EMPLOYED AT PAD A BY PUTTING TANKS IN CONCRETE VAULTS. DUE TO THE ENVIRONMENT THE TANKS ARE EXPOSED TO AT THE PADS, PROTECTION FROM BLASTS IS NEEDED. THE PROTECTION PROVIDED FOR THE EXISTING RP-1 TANKS AT PAD A (CONCRETE VAULT COVERED WITH DIRT, WITH CONCRETE PAD ON TOP) SHOULD BE SUFFICIENT. A VAPOR RECOVERY SYSTEM MAY BE REQUIRED.

LOCATING THE LRB/ET PROCESSING FACILITY IN THE GENERAL PROXIMITY OF THE PRESS SITE, AS SHOWN PREVIOUSLY IN THE LRB/ET PROCESSING FACILITY SITE PLAN, MINIMIZES THE ENVIRONMENTAL IMPLICATIONS. IT IS CONVENIENT TO THE BARGE DELIVERY SITE, AS WELL AS THE TOW ROUTE TO THE VAB. THIS WILL ELIMINATE THE NEED TO CONSTRUCT AN EXTENSIVE TOW ROUTE AND ALSO REDUCES THE IMPLICATION OF CONSTRUCTION ACTIVITIES IN WET LANDS.

HANDLING LARGE QUANTITIES OF FUEL POSES A GREATER POTENTIAL FOR GROUND WATER CONTAMINATION DURING DELIVERY, TRANSFER AND SERVICING OPERATIONS. A LARGE SPILL IN THE AREA WOULD BE DIFFICULT TO CLEAN UP DUE TO HIGH WATER TABLE AND THE PERMEABILITY OF THE SOIL. FOR THIS REASON THE OPERATIONS SHOULD OCCUR AS MUCH AS POSSIBLE OVER IMPERVIOUS SURFACES WITH SPILL CONTROL MEASURES. IN ADDITION, MONITORING WELLS WILL BE REQUIRED IN THE VICINITY OF THE STORAGE FACILITY, WHICH ARE NOT IN EXISTENCE AT THIS TIME.

MAJOR ENVIRONMENTAL IMPACTS

- RP-1 STORAGE FACILITY
  - LEAK DETECTION REQUIREMENTS
  - SPILL CONTAINMENT REQUIREMENTS
  - CONSTRUCTION REQUIREMENTS
- ET/LRB PROCESSING FACILITY
  - SELECTED LOCATION WILL DETERMINE ENVIRONMENTAL IMPACT
- GROUND WATER CONTAMINATION
  - POTENTIAL FOR GROUND WATER CONTAMINATION
  - MONITORING WELLS REQUIRED

MAJOR ENVIRONMENTAL IMPLICATIONS (CONTINUED)

THE MOST SIGNIFICANT ENVIRONMENTAL IMPLICATION IMPOSED ON ENDANGERED SPECIES IS THAT POSED BY THE INCREASED BARGE TRAFFIC FOR LRB DELIVERY ON THE MANATEE. IT IS ESTIMATED THAT 10% OF THE MANATEE POPULATION LIVE IN THE WATER SURROUNDING KENNEDY SPACE CENTER. THIS IMPLICATION CAN BE MINIMIZED BY PLACING GUARDS AROUNDS THE PROPELLER BLADES ON THE BARGE MOTOR AND POSTING MANATEE OBSERVERS ON BOARD. THE ET BARGE CURRENTLY USES THIS APPROACH.

THE MOST SIGNIFICANT IMPROVEMENT FROM AN ENVIRONMENTAL QUALITY STANDPOINT OF LRB OVER SRB IS IN THE AREA OF AIR QUALITY. DUE TO IGNITION BY-PRODUCTS AIR EMISSIONS WILL BE LESS HAZARDOUS FROM THE LRB THAN THOSE OF THE SRB. IN ADDITION, THE PROBLEM OF THE HCL CLOUD FORMED BY THE SRB IGNITION WILL BE ELIMINATED.

MAJOR ENVIRONMENTAL IMPACTS (CONT)

- ENVIRONMENTAL IMPACTS ON ENDANGERED SPECIES
  - IMPACT ON THE MANATEE
- ADVANTAGES OF LRB OVER SRB
  - IMPROVEMENT IN AIR QUALITY
  - ELIMINATION OF HCL CLOUD

KSC ADVANCED PROJECTS & TECHNOLOGY OFFICE

LIQUID ROCKET BOOSTER INTEGRATION SECOND PROGRESS REVIEW

OCT 1988

AGENDA

I. INTRODUCTION	Gordon Artley
II. STUDY PROGRESS	
A. ACHIEVEMENT SUMMARY	Pat Scott
B. ENGINE PROCESSING STUDY	Glen Waldrop
C. LRB/ET PROCESSING EVALUATION	Greg DeBlasio
D. SAFETY & ENVIRONMENTAL IMPLICATIONS	Roger Lee
E. GOCM STATUS	Stephen Schneider
III. SUMMARY	Gordon Artley

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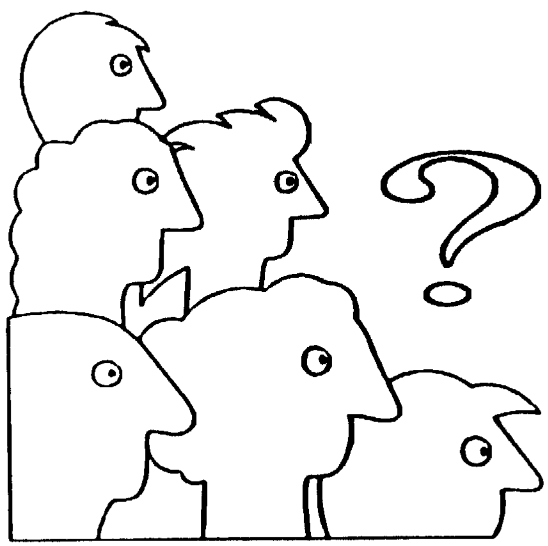
GOCM IS A PARAMETRIC MODEL

THE GROUND OPERATIONS COST MODEL, AS A PARAMETRIC MODEL, USES ONLY VERY BASIC PARAMETERS, SUCH AS HEIGHT, AREA, VOLUME OR TYPE. BASED ON THESE FUNDAMENTAL INPUTS, THE MODEL GENERATES A VARIETY OF COST ESTIMATES. THESE ESTIMATES ARE DESIGNED TO PROVIDE DEPENDABLE AND CONSISTENT ROUGH ORDER OF MAGNITUDE (ROM) DOLLAR FORECASTS. THIS IS AN IDEAL MANAGEMENT TOOL FOR "WHAT IF" OR SENSITIVITY STUDIES.

THE LIQUID ROCKET BOOSTER INTEGRATION STUDY IS IN THE PROCESS OF EVALUATING HISTORICAL COST PERFORMANCE AND CORRELATING THIS DATA WITH THE GROUND OPERATIONS COST MODEL OUTPUTS. THIS ON-GOING ANALYSIS IS VERIFYING THE MODEL's ORIGINAL CERS AND GENERATING THE INFORMATION NECESSARY TO REFINE THESE RELATIONSHIPS IN THE FUTURE. THIS HEURISTIC PROCESS WILL CONFIRM THE RELIABILITY OF THE MODEL'S FINANCIAL ESTIMATES.

E. GOCM STATUS



1. Flow Chart
2. Enhanced GOCM Software
3. GOCM User's Manual
4. "Actuals" Evaluation

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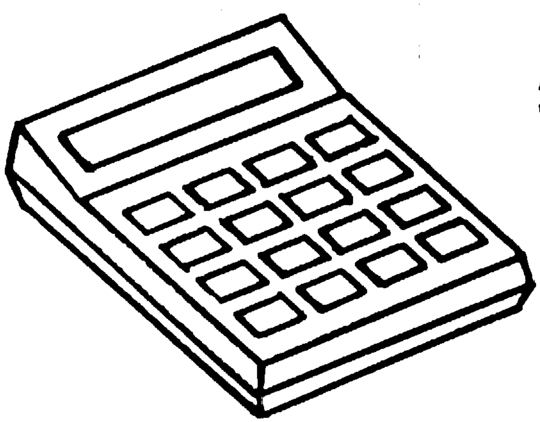
GROUND OPERATIONS COST MODEL



1. Developed by NASA
2. Parametrically generates STS/equivalent ground processing costs using fundamental inputs, e.g. booster size, generic type
3. LSOC Task 9
   expand and enhance GOCM through the incorporation of lessons learned from the LRB Integration Study
4. Task 9 Study Products
   a. User's manual
   b. Recommendations
   c. Instructions
   d. Software

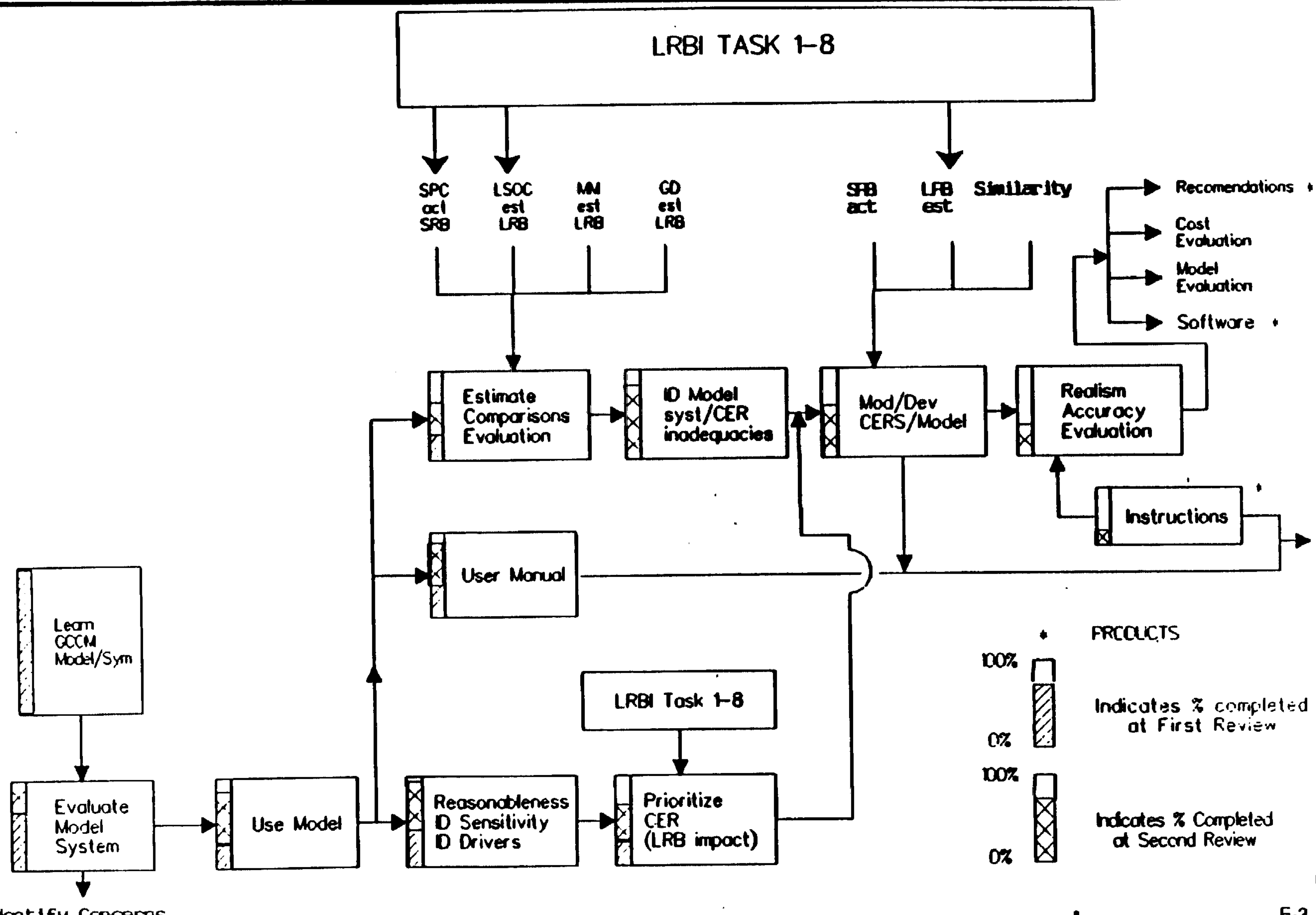
TASK 9 OVERVIEW

LSOC COST MODEL TASK CONTINUED TO BE ON SCHEDULE. COST ESTIMATING RELATIONSHIP (CER) DATA HAS BEEN COLLECTED AND IS UNDER ACTIVE EVALUATION. THIS HAS ALLOWED THE REALISM AND ACCURACY EVALUATION OF CERS IN THE ORIGINAL MODEL TO BEGIN AS PLANNED. THESE ACCOMPLISHMENTS HAVE ALLOWED US TO INITIATE PRELIMINARY CER/MODEL MODIFICATIONS AND IDENTIFY PRELIMINARY SYSTEM/CER INADEQUACIES.

THE USER'S MANUAL CONTINUED TO MOVE TOWARDS COMPLETION AS ORIGINALLY PLANNED. THE TECHNICAL INSTRUCTIONS MANUAL IS ALSO ON TARGET. THE PRELIMINARY SET OF RECOMMENDATIONS, DISCUSSED LAST PERIOD, ARE BEING REFINED THIS PERIOD.

LIQUID ROCKET BOOSTER INTEGRATION SECOND PROGRESS REVIEW

OCT 1988



2ndRev.

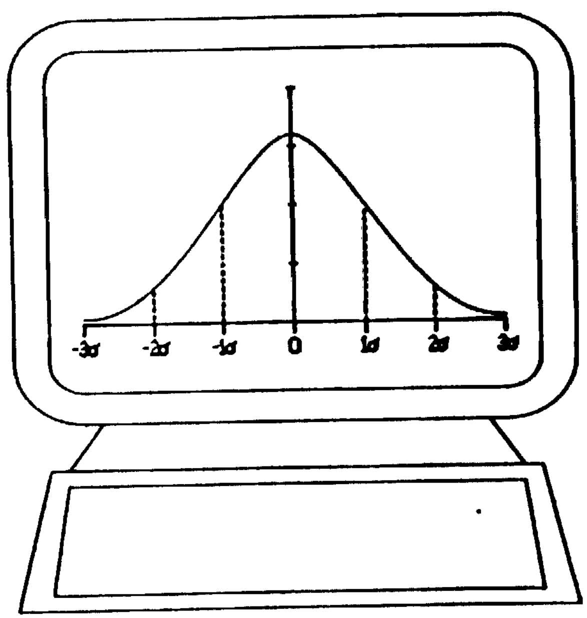
ENHANCED GOCM SOFTWARE

THE CERS OF THE ORIGINAL MODEL HAVE BEEN RETAINED. ALTHOUGH THE ORIGINAL CONCEPT IS THE SAME, IT HAS BEEN THOROUGHLY "REPACKAGED" WITH A NUMBER OF ENHANCEMENTS.

THESE ENHANCEMENTS HAD TWO GOALS. THE FIRST WAS TO ACHIEVE A HIGHER DEGREE OF USER FRIENDLINESS. THE SECOND WAS TO MAKE THE MODEL "EXPANSION READY." BOTH THESE GOALS SHOULD ALLOW INEXPERIENCED USERS TO UTILIZE GOCM AND IMPLEMENT MINOR MODIFICATIONS. ENHANCING USER FRIENDLINESS MAKES GOCM ACCESSIBLE TO A GREATER USER AUDIENCE, THEREBY EXPANDING ITS GENERAL UTILITY. THIS USER FRIENDLINESS ENCOMPASSES HELP SCREENS, USER PROMPTS AND PROMPTED MENUS.

GOCM WAS MADE EXPANSION READY IN ORDER TO READILY INCORPORATE FUTURE CER MODIFICATIONS AND ADDITIONS. AS ADDITIONAL CERS BECOME AVAILABLE, THEY CAN BE DIRECTLY INSERTED INTO AREAS ALREADY PROGRAMMED INTO THE SPREADSHEET. THIS MEANS THAT ADDITIONAL FORMULAS CAN BE EASILY INCORPORATED INTO THE SPREADSHEET WITHOUT RESTRUCTURING THE MODEL.

ENHANCED VERSION OF GOCM NEAR COMPLETION



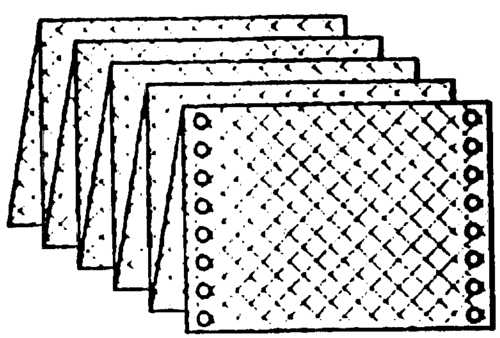
1. Preserved original CERs
2. Enhanced user friendliness
3. GOCM is expansion ready

Result: Inexperienced users can now use GOCM effectively

GOCM USER'S MANUAL

THE GOCM USER'S MANUAL FOLLOWS THE MODULAR DESIGN OF THE GOCM PROGRAM. EACH PROGRAM MODULE HAS ITS OWN COUNTERPART IN THE USERS MANUAL. AN OUTLINE STYLE (WITH SCREEN FACSIMILES) ALLOWS EASY ACCESS TO FULL EXPLANATIONS. THIS SUPPLEMENTS THE EXTENSIVE ON-SCREEN USER HELP. THE LESSON LEARNED FROM INEXPERIENCED-USER FEEDBACK, OBTAINED DURING CLINICAL TRIALS OF MANUAL/SOFTWARE, ARE BEING INCORPORATED INTO THE MANUAL ON A CONTINUING BASIS.

DRAFT GOCM USER'S MANUAL NEAR COMPLETION



1. Follows program modular design

2. User friendly
   a. Menus fully documented
   b. Grammatik III evaluation

3. Complete manual testing
   a. Inexperienced subjects used
   b. Lessons learned incorporated

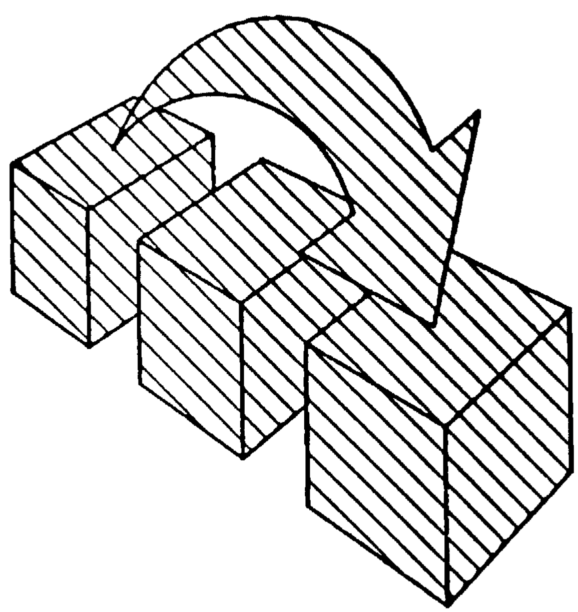
"ACTUALS" EVALUATION

GOCM MODELS KSC AND THE GROUND PROCESSING ACTIVITY IN A REALISTIC MANNER. WE ARE CURRENTLY PERFORMING AN ASSESSMENT OF ACCURACY. THIS ASSESSMENT CONCENTRATES ON TWO COST CATEGORIES: THE PROCESSING SHIFTS/MANPOWER AND COST OF FACILITIES.

THE WORK BREAKDOWN STRUCTURE ACCOUNTING RECORDS FOR JAN 85 - DEC 85 WERE EVALUATED BY FLIGHT ELEMENT AND STATION SET. THIS WILL ALLOW US TO EFFECTIVELY EVALUATE THE GOCM PROCESSING CERS AND FACILITY O&M CERS.

USING HISTORICAL DATA, WE DERIVED A FORM OF LEARNING CURVE FOR THE GROUND PROCESSING ACTIVITY. THIS GROUND PROCESSING CURVE WILL BE USED IN THE GOCM MODEL. FURTHER DETAILS AND BACKUP WILL BE PROVIDED IN THE FINAL REPORT.

"ACTUALS" EVALUATION IN PROGRESS



1. SPC WBS manhours for Jan 85-Dec 85 collected and sorted by:
   a. Flight element
   b. Work station

2. We can now more accurately
   a. assess GOCM processing CERs
   b. verify facility O&M CERs

3. Learning curve assessment with empirical data now in progress

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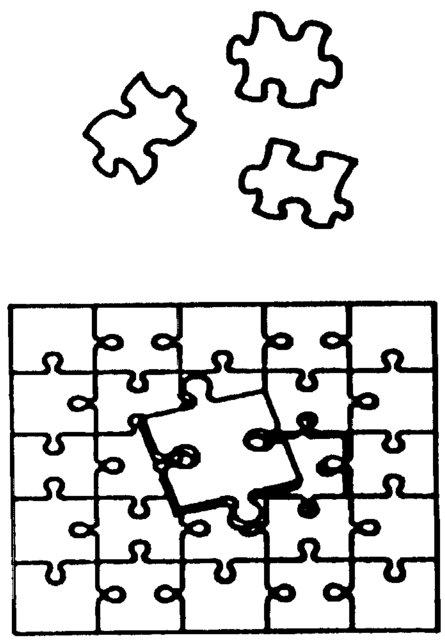
GROUND OPERATIONS COST MODEL

Next Period's Goals



1. Totally complete a thorough evaluation of the original and enhanced GOCM
2. Deliver a commercial quality software product usable by inexperienced personnel
3. Deliver a complete and understandable User's Manual
4. Deliver a technically accurate and detailed set of program instructions
5. Deliver a practical and useable set of future recommendations
6. Present a Final Oral Report

AGENDA

I. INTRODUCTION	Gordon Artley
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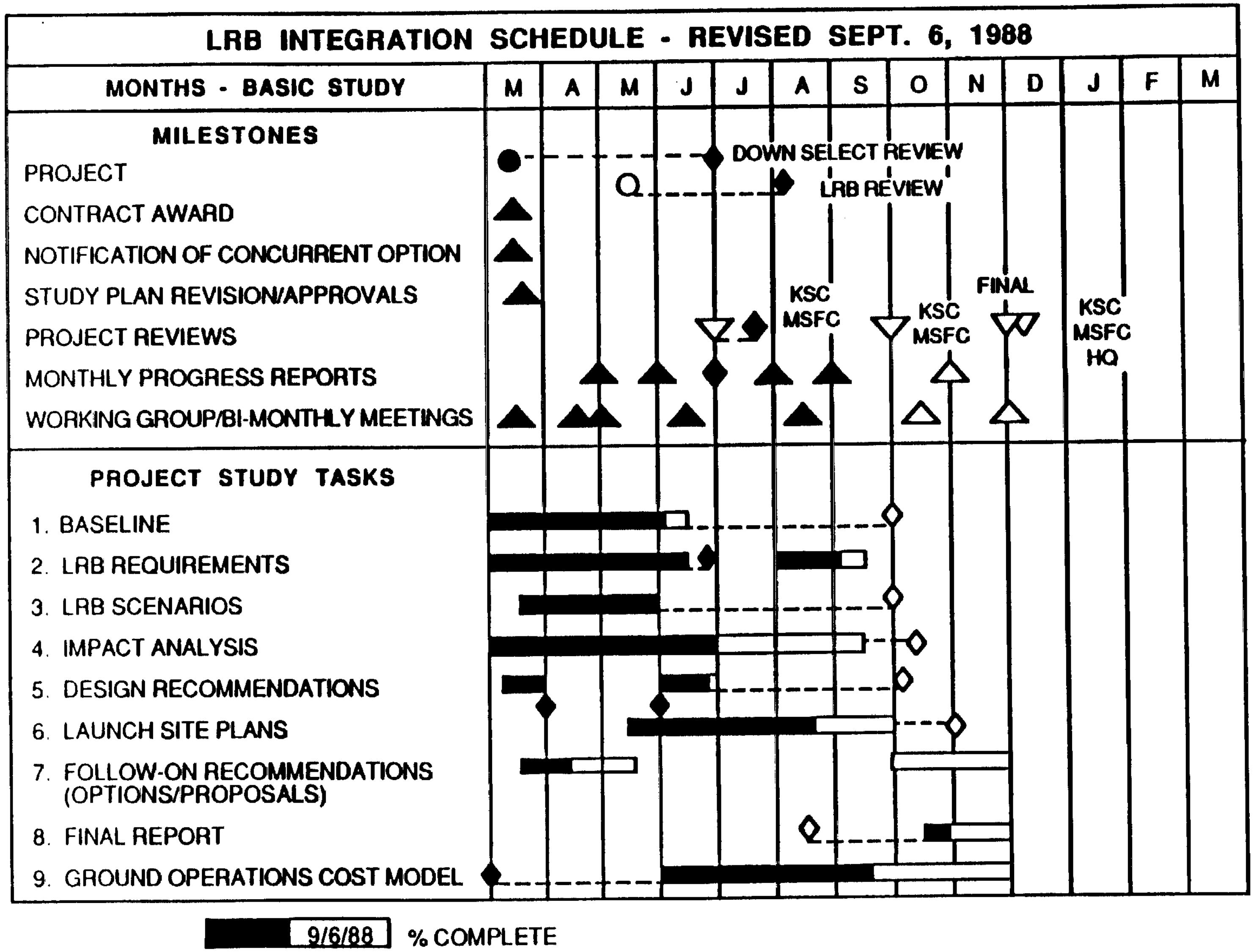
KSC ADVANCED PROJECTS & TECHNOLOGY OFFICE

LIQUID ROCKET BOOSTER INTEGRATION SECOND PROGRESS REVIEW

OCT 1988



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PRIME LRB IMPACTS

- LRB INTEGRATION DISRUPTIVE TO ONGOING OPERATIONS
- ACHIEVEMENT OF 1990's BASELINE MANIFEST REQUIRES IMPROVED AUTOMATED MANAGEMENT INFORMATION SYSTEMS AND PROCESS CONTROL
- NEW MOBILE LAUNCHER DESIGN
- ENGINE EXHAUST TRENCH/DEFLECTOR TO ACCOMMODATE BOTH LRB AND SRB
- PAD AND HIBAY 3 DESIGN FOR BOTH LRB AND SRB

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LSOC PARTICIPATION IN LRB WORKING GROUP

ISSUES:

- WORK PRIME LRB IMPACTS TO KSC
- REFINEMENT OF THE LRB DESIGN
- DEVELOPMENT OF IGNITION AND LAUNCH SEQUENCE
- APPLICATION OF LRB CONCEPTS TO ALTERNATE VEHICLES

OBJECTIVES FOR FINAL PERIOD

THE FINAL REPORT WILL RESPOND TO ALL THE STUDY OBJECTIVES AND PROVIDE THE FOLLOWING PLANS AND PRODUCTS:

1. LRB GROUND OPERATIONS PLAN
2. LRB PROCESSING TIMELINES
3. LRB FACILITY REQUIREMENTS AND CONCEPTS FOR NEW FACILITIES
4. LRB LAUNCH SUPPORT EQUIPMENT DEFINITION
5. LRB GROUND SUPPORT EQUIPMENT DEFINITION
6. LRB MANPOWER
7. COST ESTIMATES INCLUDING TRANSITION
8. POTENTIAL IMPACTS TO ON-GOING LAUNCH SITE ACTIVITY
9. PRELIMINARY TRANSITION PLAN
10. POTENTIAL ENVIRONMENTAL AND SAFETY IMPLICATIONS
11. PROPELLANT ACQUISITION STORAGE AND HANDLING REQUIREMENTS
12. RECOMMENDED CHANGES TO LRB DESIGN FOR OPERATIONAL EFFICIENCY
13. A DETAILED USERS' MANUAL FOR GOCM OPERATION
14. INSTRUCTIONS FOR UPDATING/MODIFYING THE GOCM PROGRAM
15. ALL SOFTWARE DEVELOPED
16. RECOMMENDATIONS FOR FOLLOW-ON STUDY ACTIVITY
17. VLS ASSESSMENT
18. ENGINE SHOP REQUIREMENTS
19. LRB/ET HORIZONTAL PROCESSING FACILITY

FINAL PERIOD PLANS

- PREPARE THE FINAL LRBI ORAL PRESENTATIONS
- PREPARATION OF THE FINAL REPORT

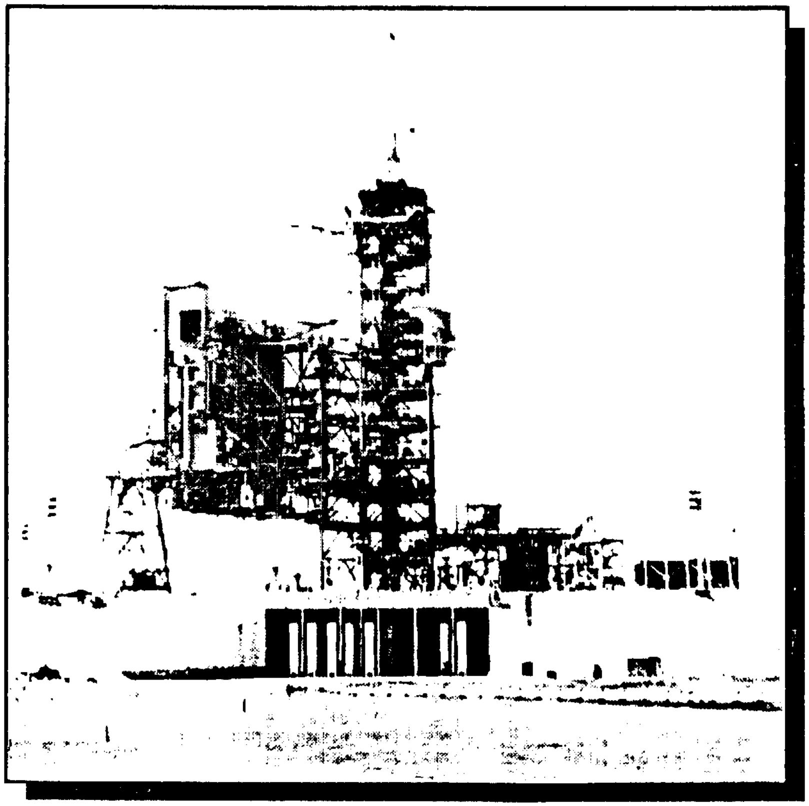
VOLUME IV

SECTION 7

FINAL PROGRESS REVIEW

November, 1988

KSC ADVANCED PROJECTS & TECHNOLOGY OFFICE



LIQUID ROCKET BOOSTER INTEGRATION STUDY

FINAL ORAL PRESENTATION

KENNEDY SPACE CENTER
NAS10-11475

Lockheed
Space Operations Company

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LIQUID ROCKET BOOSTER INTEGRATION

AGENDA

I. INTRODUCTION	Gordon Artley
II. LRBI RESULTS	
BASELINE / LAUNCH SITE SCENARIO	Pat Scott
FACILITIES AND GROUND SYSTEMS	Greg DeBlasio
IMPLEMENTATION	Gordon Artley
COST	Jerry Lefebvre
III. SUMMARY	Gordon Artley

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LRB PROGRAM OBJECTIVE

PURPOSE: ASSESS THE FEASIBILITY OF REPLACING SOLID ROCKET BOOSTERS WITH LIQUID ROCKET BOOSTERS

APPROACH: DEFINE OPTIMUM PUMP-FED AND PRESSURE-FED BOOSTERS AND THEIR IMPLEMENTATION PLANS

GOALS: INCREASE SAFETY AND RELIABILITY WITH MINIMUM IMPACT TO STS INTEGRATION AND PROVIDE INCREASED PERFORMANCE

KSC ADVANCED PROJECTS & TECHNOLOGY OFFICE

LRBI FINAL ORAL PRESENTATION

KSC - LRBI STUDY OBJECTIVES

THE STUDY METHODOLOGY USED TO ACHIEVE THE LRBI OBJECTIVES UTILIZED STUDY TASKS TO CREATE END PRODUCTS.

	STUDY PRODUCTS \ TASKS	1 SRB BASELINE	2 LRB REQUIREMENTS	3 LRB SCENARIOS	4 IMPACTS / ANALYSIS	5 LRB DESIGN RECOMMENDATION	6 LAUNCH SITE PLAN	7 FOLLOW-ON RECOMMENDATION	8 FINAL REPORT	9 GROUND OPS COST MODEL
1	LRB GROUND OPS PLAN	X					X		X	
2	LRB TIMELINES	X		X						
3	FACILITY REQMTS/CONCEPT		X		X					
4	LAUNCH SUPPORT EQUIPMENT		X		X					
5	GROUND SUPPORT EQUIPMENT		X		X					
6	LRB MANPOWER		X				X			
7	COST ESTIMATES & TRANSITIONS						X			
8	IMPACTS TO ON-GOING ACTIVITIES			X						
9	PRELIMINARY TRANSITION PLAN	X					X			
10	ENVIRONMENTAL/SAFETY ISSUES				X					
11	PROPELLANT STORAGE/HANDLING		X		X					
12	DESIGN REC/OPER EFFICIENCY	X				X				
13	GOCM USER MANUAL									X
14	GOCM INSTRUCTIONS									X
15	GOCM SOFTWARE									X
16	FOLLOW-ON RECOMMENDATIONS							X		
17	VLS ASSESSMENT FOR LRB		X				X			
18	LRB ENGINE PROCESSING REQUIRES		X		X					
19	LRB/ET HPF				X				X	

Lockheed Space Operations Company

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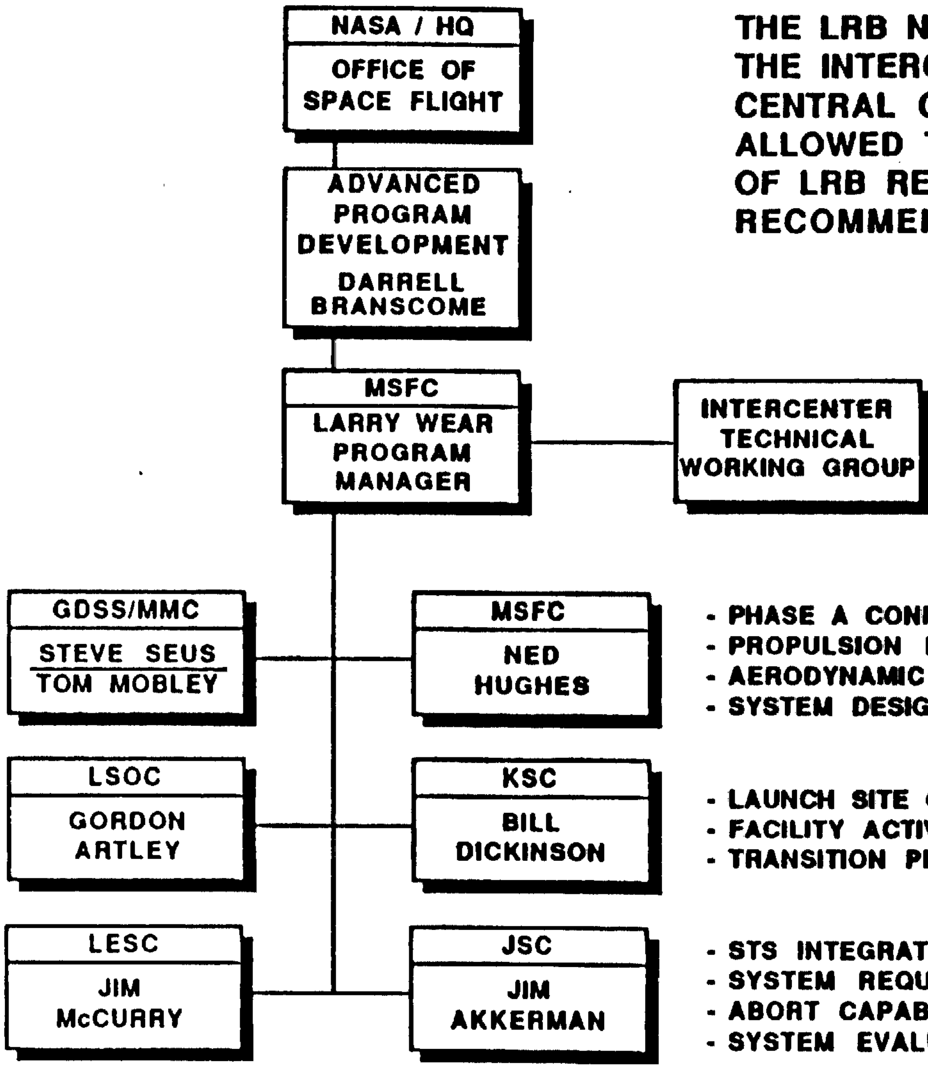
KSC - LRBI STUDY OBJECTIVES

- DEFINE FACILITY IMPACTS
- DEVELOP OPERATIONAL SCENARIOS
- PROVIDE BOOSTER DESIGN RECOMMENDATIONS
- PROMOTE OPERATIONAL EFFICIENT LRB SYSTEMS
- PERFORM COST ASSESSMENT UTILIZING GOCM
- GENERATE PRELIMINARY PROCESSING LSE-GSE REQUIREMENTS
- CREATE LAUNCH SITE SUPPORT PLAN

STUDY APPROACH

THE LRB NASA / CONTRACTOR TEAM USED THE INTERCENTER WORKING GROUP AS THE CENTRAL COMMUNICATIONS POINT. THIS ALLOWED THE FULL AND EFFECTIVE EXCHANGE OF LRB REQUIREMENTS / LRBI IMPACTS AND RECOMMENDATIONS.

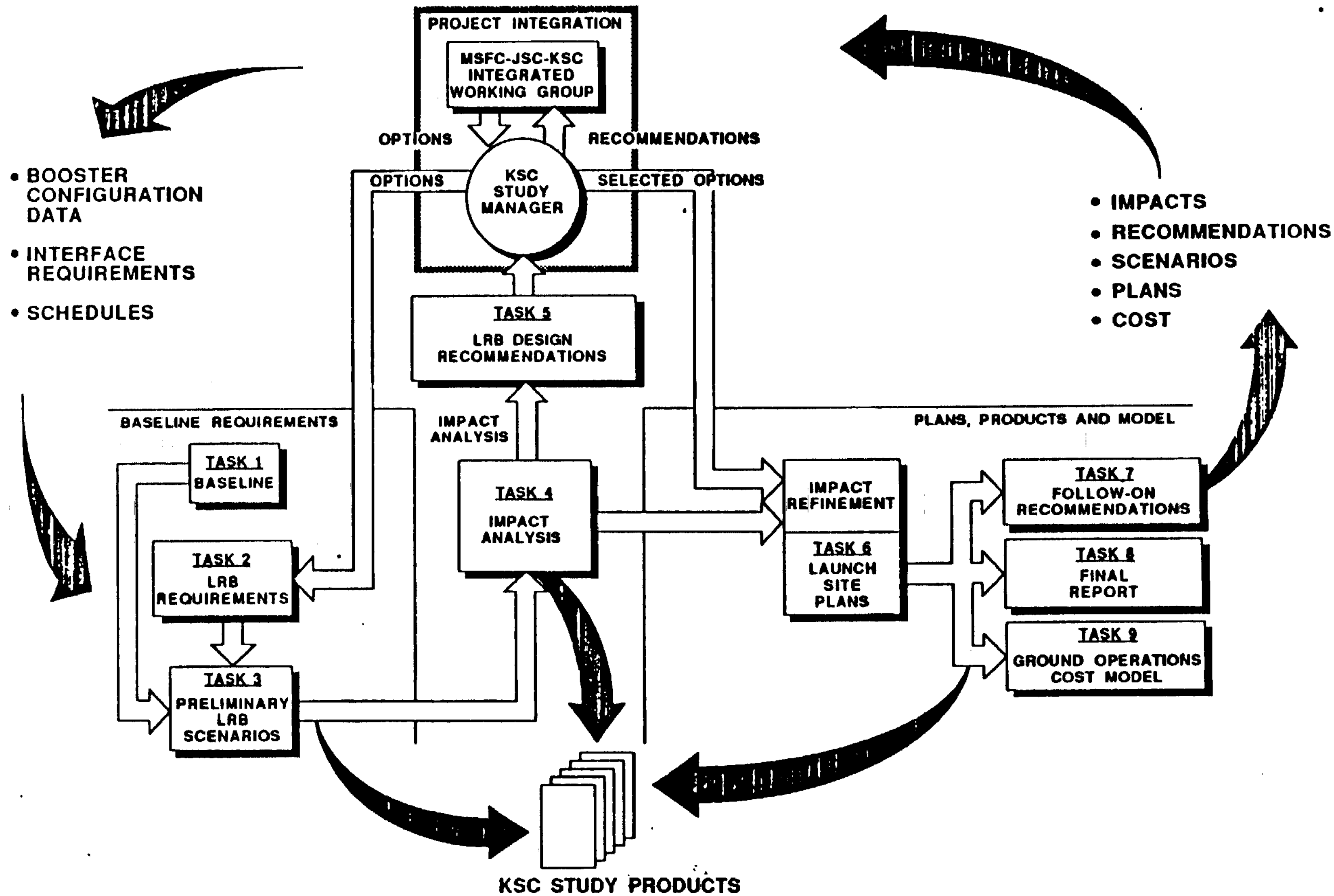


- PHASE A CONFIGURATION STUDY
- PROPULSION EVALUATION
- AERODYNAMIC SUPPORT
- SYSTEM DESIGN STUDIES

- LAUNCH SITE OPS INTEGRATION
- FACILITY ACTIVATION
- TRANSITION PLANNING

- STS INTEGRATION
- SYSTEM REQUIREMENTS
- ABORT CAPABILITIES
- SYSTEM EVALUATION

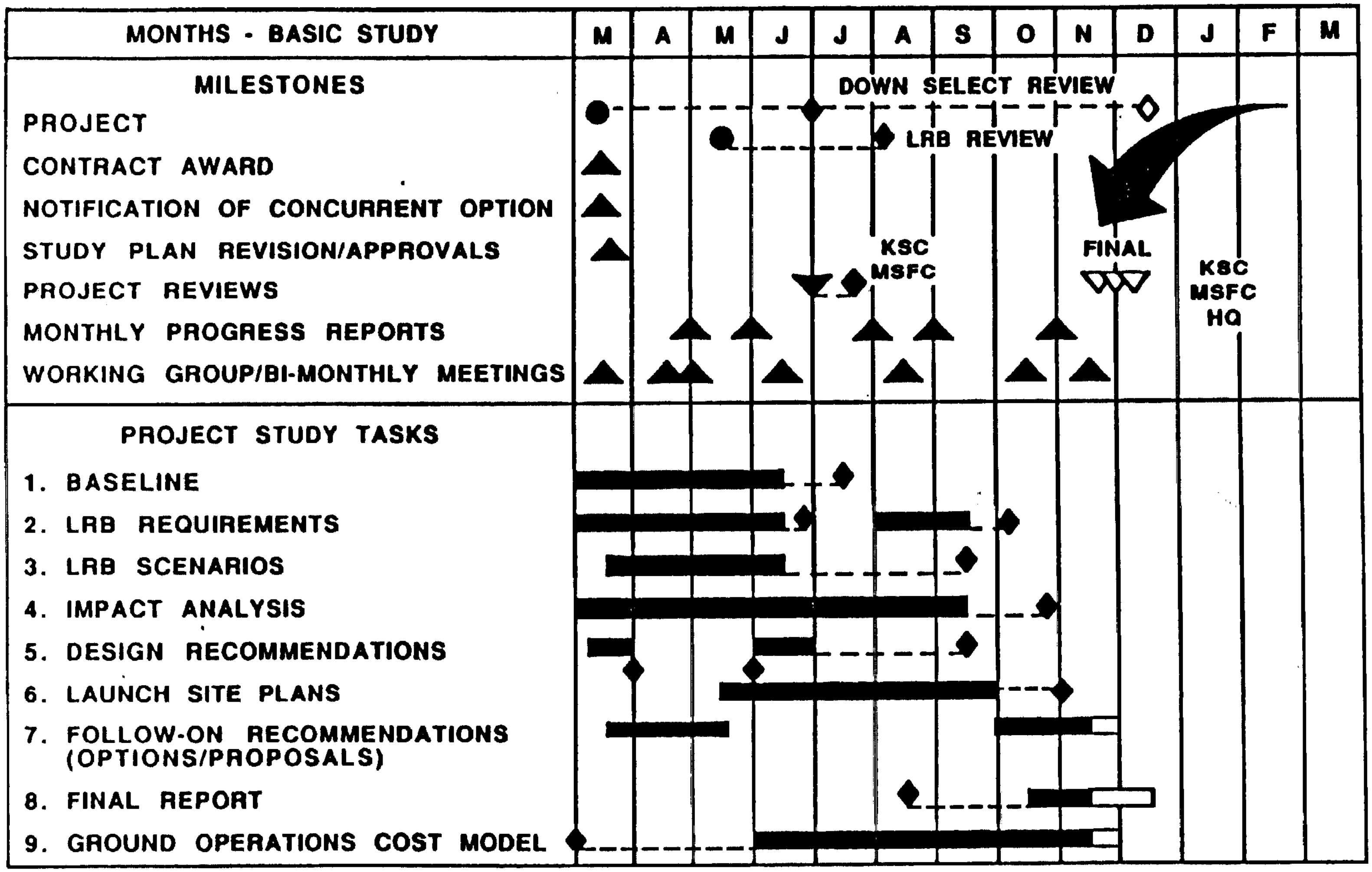
STUDY APPROACH



THIS REPORT IS THE RESULT OF NINE MONTHS OF STUDY UNDER NAS10-11475, APRIL 15, 1988, "LIQUID ROCKET BOOSTER INTEGRATION STUDY." UNDER THE DIRECTION OF WILLIAM J. DICKINSON OF THE NASA/KSC FUTURE PROJECTS OFFICE, THE STUDY COMBINED THE TALENT AND EFFORTS TO THE LOCKHEED SPACE OPERATIONS COMPANY, PAN AMERICAN WORLD SERVICES, AND ROCKETDYNE, INC. THE PRINCIPAL STUDY TEAM CONTRIBUTORS WERE:

GORDON ARTLEY	LOCKHEED STUDY MANAGER
STEVEN BURNS	GROUND OPERATIONS PLAN/FACILITY ACTIVATION
DEBORAH CANNADAY	TECHNICAL EDITOR
GREGORY DEBLASIO	FACILITY, PROPELLANTS, GSE/LSE REQUIREMENTS
H. GENE ELLIS (PAN AM)	MANPOWER ANALYSIS
KEITH HUMPHRYES (PAN AM)	OPERATIONS ANALYSIS/LAUNCH SITE PLAN
DR. WILLIAM HUSEIONICA (PAN AM)	PROCESSING ANALYSIS
ROBERT KELLAR (PAN AM)	IMPLEMENTATION PLAN
KENNETH LATHROP (PAN AM)	TRANSITION PLAN/MANPOWER
ROGER LEE	SAFETY AND ENVIRONMENTAL IMPLICATIONS
GERALD LEFEBVRE	COST MODELING/ANALYSIS
JANET MOODY	GRAPHICS COMPILATION
PEERI PAPPAS, P.E.	GROUND OPERATIONS COST MODEL
STEPHEN SCHNEIDER	GROUND OPERATIONS COST MODEL
LELAND P. SCOTT	LOCKHEED DEPUTY STUDY MANAGER
JAMES TEFFT	VLS ASSESSMENTS
GLEN WALDROP (ROCKETDYNE)	ENGINE SERVICING/OPERATIONS

LRB INTEGR TION SCHEDULE



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LRB STUDY FINDINGS

FACILITY IMPACTS	MODIFY VAB HB-3 AND HB-4, PADS A AND B PROVIDE 2 NEW MLPs, AND ET/LRB HPF REACTIVATE MLP #2 PARKSITE
OPERATIONAL SCENARIOS	ACTIVATION PHASE, SRB/LRB PHASE SUSTAINED LRB LAUNCH OPERATIONS PHASE
BOOSTER RECOMMENDATIONS	60% OF RECOMMENDATIONS INCORPORATED
EFFICIENT LRB SYSTEMS	ACCOMMODATED THE LRB PROGRAM LIFE CYCLE COST GOALS
COST ASSESSMENT	ENHANCE GOCM AND BOTTOM-UP ASSESSMENT
PROCESSING LSE/GSE REQUIREMENTS	VOLUME III, SECTION 4 AND 5 FINAL REPORT
LAUNCH SITE PLAN	IMPLEMENTATION PLAN/MANPOWER/IPOP

LIQUID ROCKET BOOSTER INTEGRATION

AGENDA

I. INTRODUCTION	Gordon Artley
II. LRBI RESULTS	
BASELINE / LAUNCH SITE SCENARIO	Pat Scott
FACILITIES AND GROUND SYSTEMS	Greg DeBlasio
IMPLEMENTATION	Gordon Artley
COST	Jerry Lefebvre
III. SUMMARY	Gordon Artley

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LRBI BASELINE AND LAUNCH SITE SCENARIO

- MSFC PHASE A STUDY RESULTS
- SELECTED LRB CONFIGURATIONS
  - MMC
  - GDSS
- LIQUID ENGINE DESIGNS
- LAUNCH SITE LRB DESIGN RECOMMENDATIONS
- GROUND SYSTEM DESIGN ISSUES

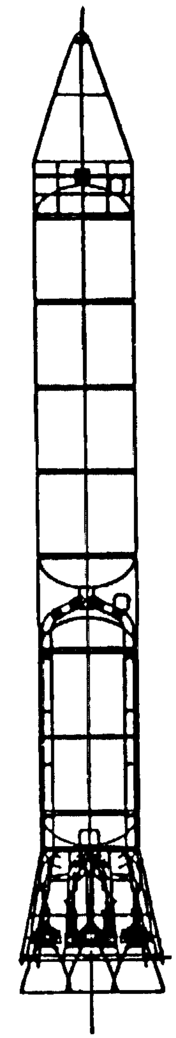
MSFC PHASE-A STUDY FINDINGS

- o GDSS AND MMC STUDIES HAVE RESULTED IN THESE BASIC FINDINGS.
- o A SELECTION OF PRELIMINARY LRB DESIGNS FOR BOTH PUMP AND PRESSURE-FED SYSTEMS HAS BEEN MADE.
- o THE KSC "MODERATE" IMPACTS ARE ADDRESSED IN THIS PRESENTATION

SUMMARY OF MSFC PHASE-A LRB FINDINGS

MSFC LRB STUDY FINDINGS

- LRB SHOULD BE EXPENDABLE BOOSTER
- ALL CONFIGURATIONS ARE 4-ENGINED
- NEW LOW-COST ENGINE DEVELOPMENT IS REQUIRED
- LOX/RP-1 IS FAVORED PROPELLANT FOR STS
- LOX / LH2 PUMP-FED IS PREFERRED FOR ALTERNATE APPLICATIONS
- BOTH PUMP AND PRESSURE-FED OPTIONS ARE VIABLE (PRESSURE-FED REQUIRES TECHNOLOGY DEVELOPMENTS)
- ALL SELECTED CONFIGURATIONS CAN BE FLOWN WITHIN CURRENT STS CONSTRAINTS
- LRB WILL IMPACT KSC "MODERATELY"
  - —BOOSTER DIAMETERS (13.9 TO 18.0 FEET)
  - —BOOSTER LENGTHS (147 TO 197 FEET)
  - —ET / ORBITER INTERFACES MAINTAINED
  - —LIFT-OFF UMBILICALS BASELINED



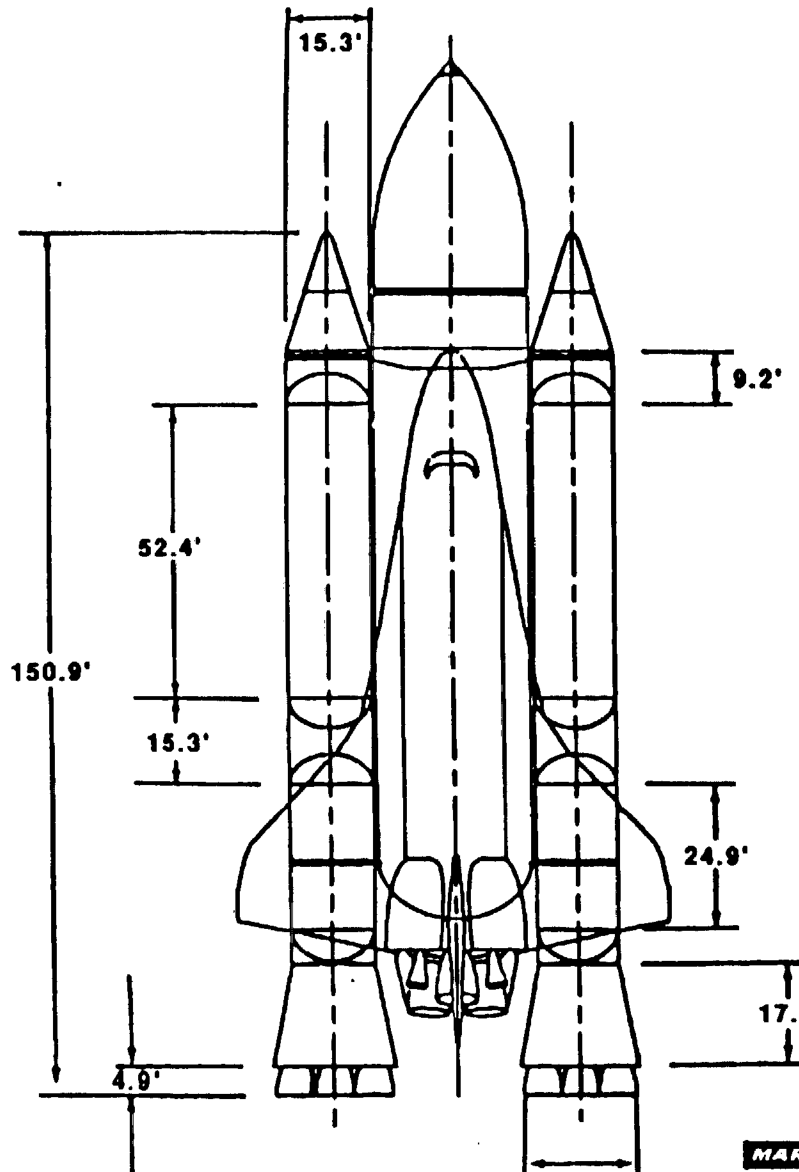
LRB SELECTED CONFIGURATIONS

(MARTIN MARIETTA)

C-8

- PUMP-FED CONFIGURATION IS SHOWN HERE. DUAL 17-INCH FEED LINES ROUTE THE LOX AROUND THE RP-TANK. FORWARD THRUST ATTACH POINT IS LOCATED IN LRB FORWARD SKIRT AREA. AFT ATTACH IS IN MID-TANK AREA WHERE LOWER TRANSVERSE LOADS ARE DISTRIBUTED THROUGH A DEEP RING STIFFENER WITHIN THE TANK. DIAMETER AND LENGTH DIMENSIONS ARE CLOSEST TO SRB.

MMC PUMP-FED LO2 / RP-1 CONFIGURATION



MARTIN MARIETTA
MANNED SPACE SYSTEMS

81012-02J-V/G
/JF2

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Space Operations Company

MMC PUMP-FED LO2/RP-1 CONFIGURATION

VEHICLE DIMENSIONS	
o LENGTH (IN)	1,810.7
o DIAMETER (OD-IN)	183.0
o ENGINE EXIT AREA (IN^2)	7,359
PROPELLANT VOLUMES (FT^3)	
o LO2	10,769
o RP-1	5,798
o FEEDLINES	245
WEIGHT (LB) INCLUDES 10% CONTINGENCY	
o STRUCTURE	77,840
o PROPULSION SYSTEM	34,820
o OTHER SUBSYSTEMS	11,060
DRY WEIGHT	123,720
o USABLE IMPULSE PROPELLANT	
o LO2	701,302
o RP-1	268,698
o RESIDUALS GASES AND LIQUIDS	5,335
PROPELLANTS/GASES	975,335
GLOW (GROSS LIFTOFF WEIGHT)	1,099,055

$\boxed{10\% < SRB}$

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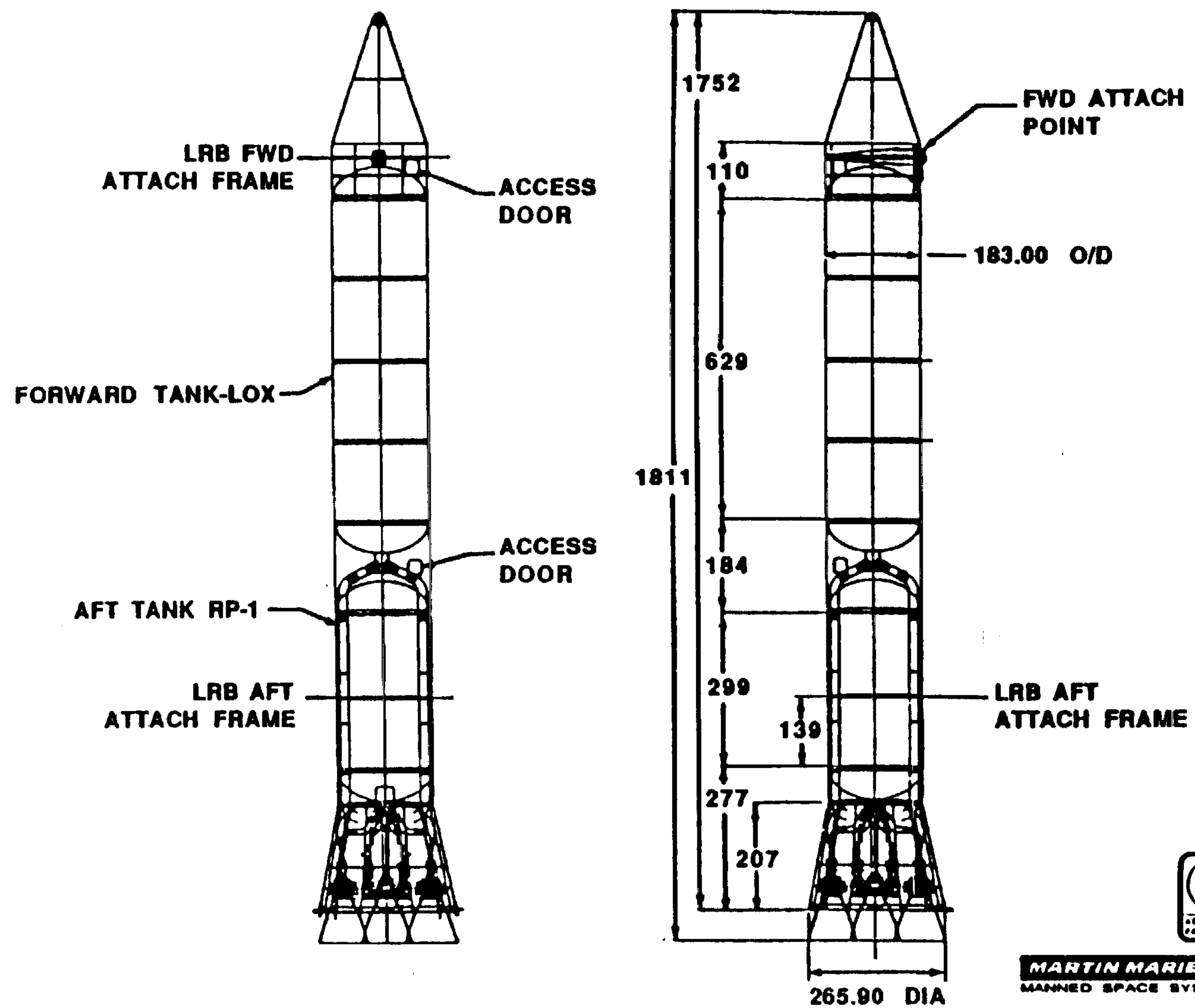
MMC PUMP-FED LO_2 / RP-1 CONFIGURATION

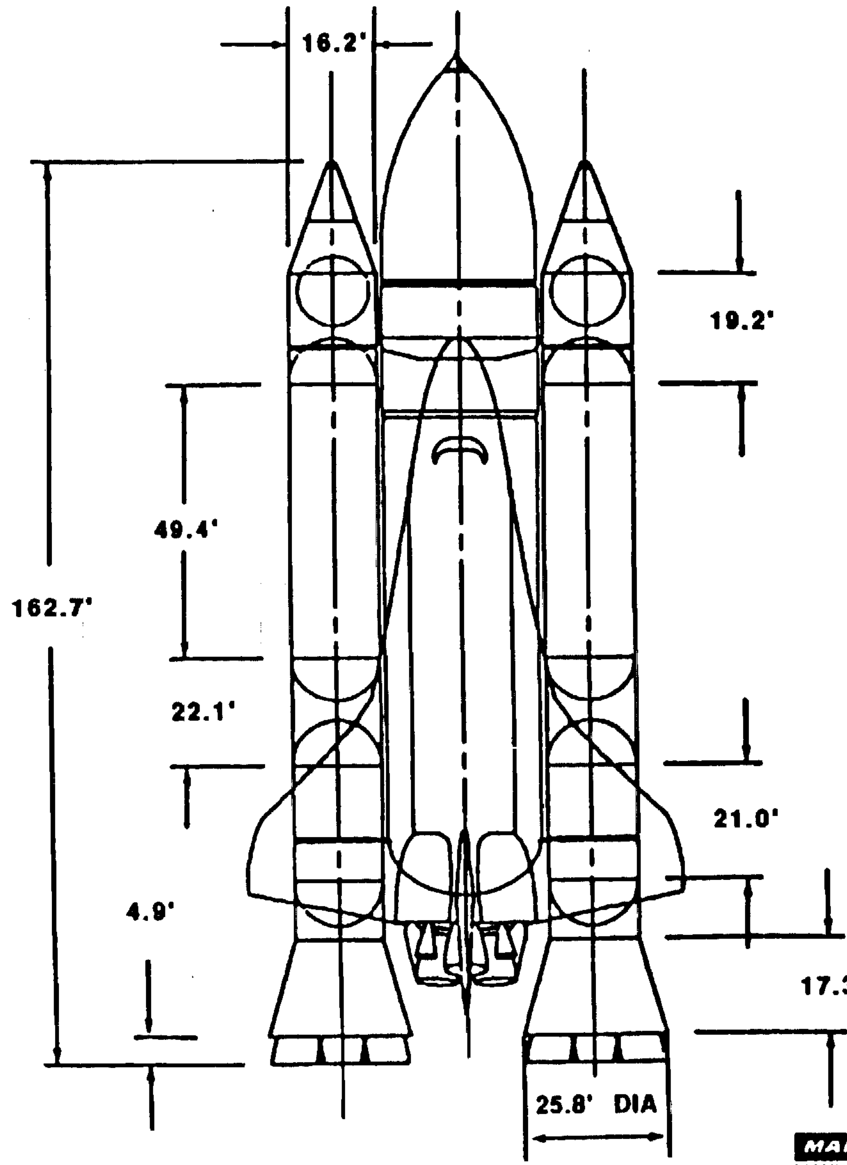


LRB SELECTED CONFIGURATIONS

(MARTIN MARIETTA)

- PRESSURE-FED CONFIGURATION IS SIGNIFICANTLY LARGER. TANK WALL THICKNESSES ARE APPROXIMATELY 1-INCH. ENGINE CHAMBER PRESSURES REQUIRE HIGH TANK PRESSURES AND A PRESSURIZATION SYSTEM OF 3000 - 4000 psi. HIGHER PROPELLANT LOADING INCREASES GROSS LIFT OFF WEIGHT TO 1.3 M POUNDS WHICH IS HEAVIER THAN CURRENT SRB. HIGHER ENGINE THRUST IS REQUIRED (APPROXIMATELY 750K EACH.)

MMC PRESSURE-FED LO2/RP-1 CONFIGURATION



MARTIN MARIETTA
MANNED SPACE SYSTEMS

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MMC PRESSURE-FED LO2/RP-1 CONFIGURATION

VEHICLE DIMENSIONS	
o LENGTH (IN)	1,952.0
o DIAMETER (OD-IN)	194.0
o ENGINE EXIT AREA (IN^2)	9,365
PROPELLANT VOLUMES (FT^3)	
o LO2	12,012
o RP-1	6,328
o FEEDLINES	214
WEIGHT (LB) INCLUDES 10% CONTINGENCY	
o STRUCTURE	166,760
o PROPULSION SYSTEM	44,030
o OTHER SUBSYSTEMS	10,730
DRY WEIGHT	221,520
o USABLE IMPULSE PROPELLANT	
o LO2	782,084
o RP-1	292,916
o RESIDUALS GASES AND LIQUIDS	5,910
o HELIUM-PRESSURE SYSTEM	11,790
o PROPELLANT-PRESSURE SYSTEM	22,560
PROPELLANTS/SYSTEMS	1,115,260
GLOW (GROSS LIFTOFF WEIGHT)	1,336,780

7% > SRB

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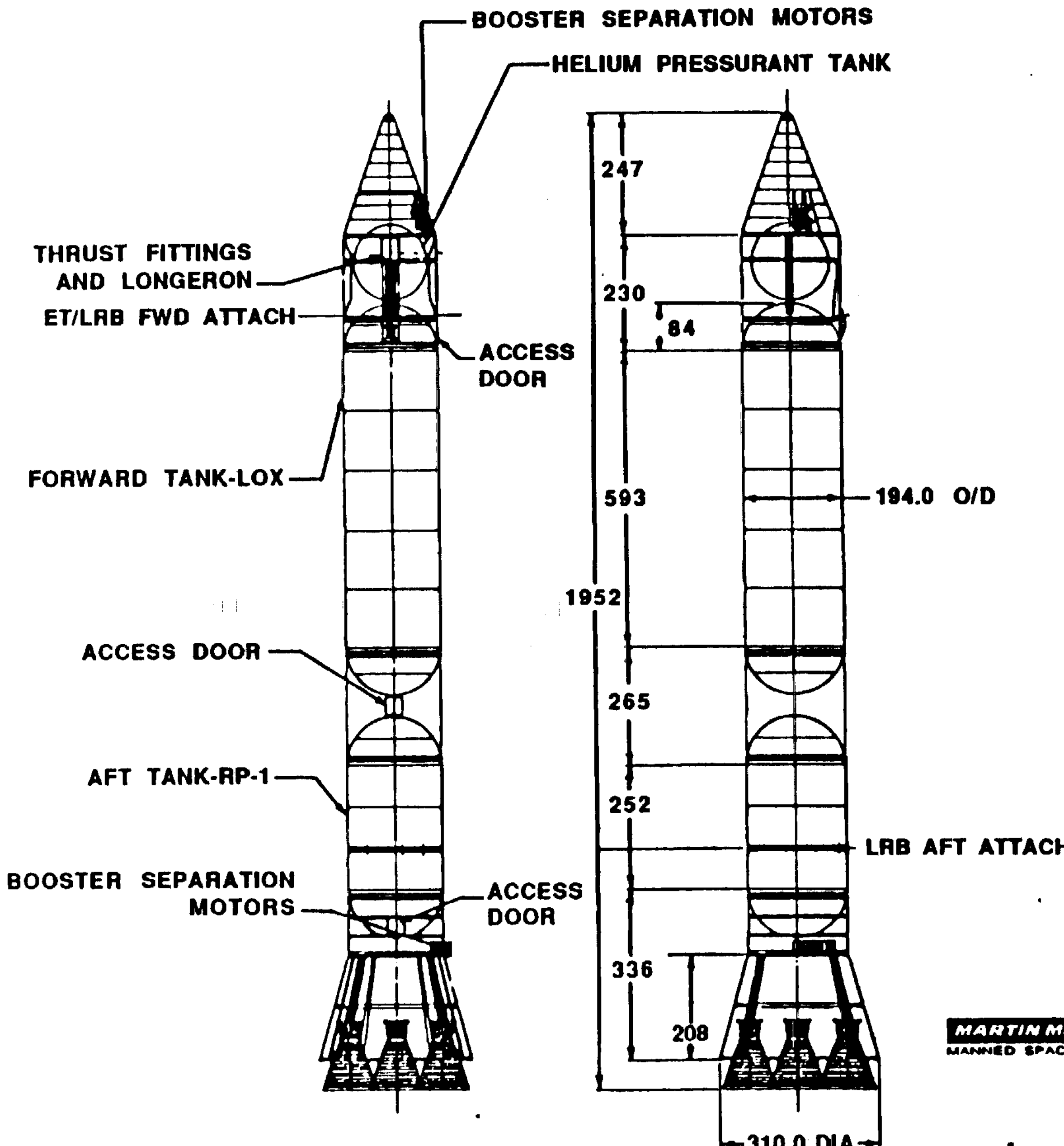
A

MMC PRESSURE-FED LO2 / RP-1 CONFIGURATION



LRB SELECTED CONFIGURATIONS

(GENERAL DYNAMICS)

- PUMP-FED AND PRESSURE-FED LOX/RP1 CONFIGURATIONS ARE SIZED AS SHOWN. PUMP-FED SIZING IS CLOSEST TO SRB DIMENSIONS. PRESSURE-FED IS THE LARGEST AND USES CENTERED LOX FEED LINE THROUGH LOWER FUEL TANK. LENGTH OF PRESSURE-FED IS EXTREME.

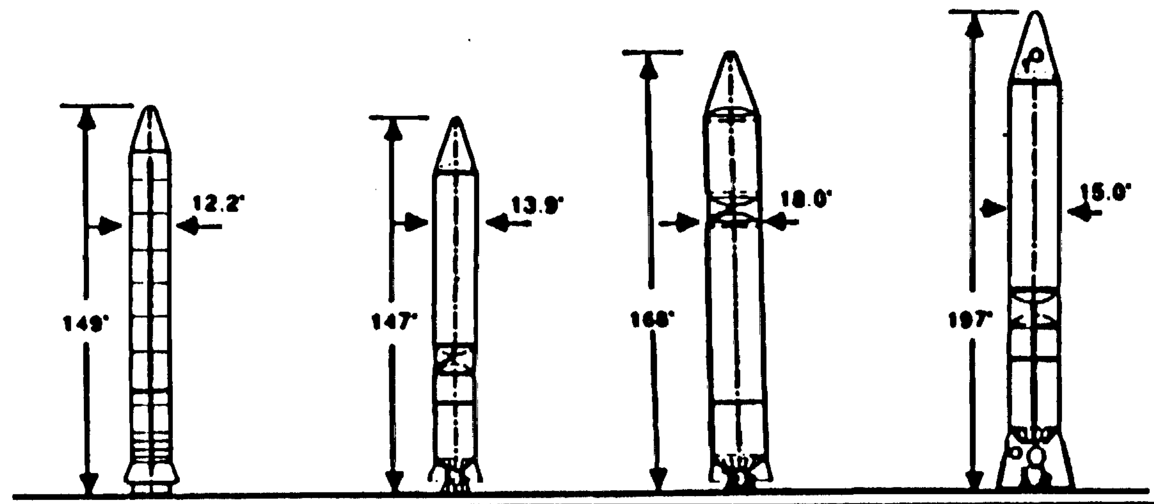
- THE LOX/LH_2 CONFIGURATION HAS BEEN SELECTED AND IS THE TARGET OF SOME RESIZING STUDIES. SHORTENED LENGTH ALLOWS CLEARANCE FOR ET GOX VENT ARM AT PAD, WHILE RESULTING DIAMETER GROWS TO NEAR 18 FT.

- STUDIES ASSOCIATED WITH LOX/CH4 SPLIT EXPANDER HAVE SHOWN NO SIGNIFICANT ADVANTAGES AND THIS CONFIGURATION HAS BEEN DELETED. HOWEVER, THE ENGINE DESIGN IS BEING EVALUATED AS AN OPTION FOR THE LOX/LH2 CONFIGURATION.

GDSS SELECTED LRB CONFIGURATIONS

OCT. 1988

GENERAL DYNAMICS
Space Systems Division



DATA (ONE BOOSTER)	SOLID ROCKET BOOSTER	LO2/RP-1 PUMP-FED	LO2/LH2 * PUMP-FED	LO2/RP-1 PRESS-FED
DRY WEIGHT (K lbs)	146	104	131	216
STRUCTURE (K lbs)	-	46.7	75.6	127
LRB GLOW (K lbs)	1,250	1,032	775	1,602
THRUST PER ENGINE (sea level)(K lbs)(nominal)	2,912	546	481	850
INITIAL T/W	1.5	1.37	1.34	1.54
BECO (sec)	120	123	126	119

* ALTERNATE: SPLIT EXPANDER CYCLE

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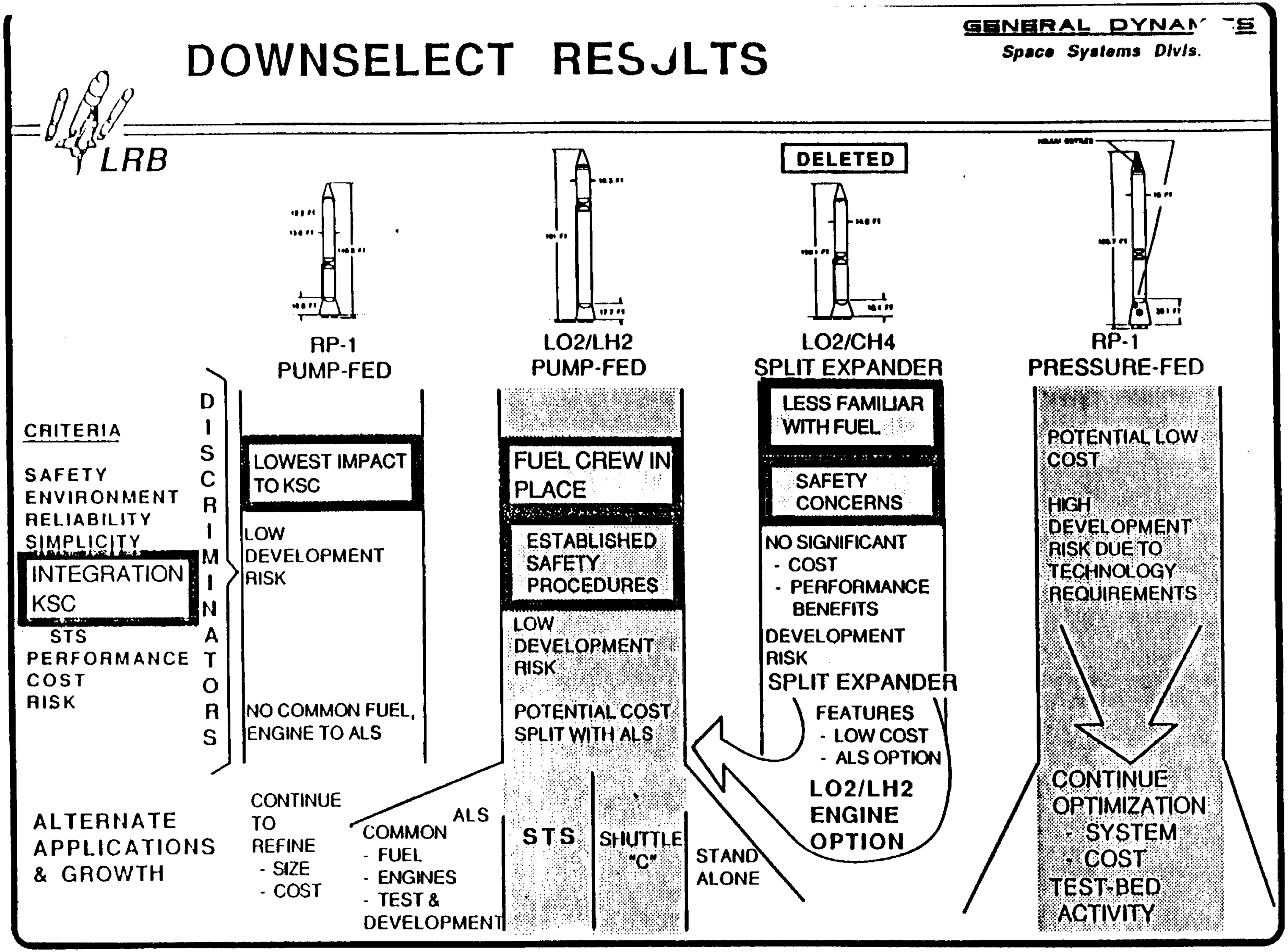
DOWN-SELECTION CRITERIA

(GENERAL DYNAMICS)

- GD's DOWNSELECT RESULTS INDICATE THE ATTENTION GIVEN TO KSC LAUNCH SITE INTEGRATION AS A PROMINENT CRITERIA (NOTE THE HIGHLIGHTED AREAS).


DOWNSELECT RESULTS
GENERAL DYNAMICS
Space Systems Divis.
LRB
DELETED
RP-1
PUMP-FED
LO2/LH2
PUMP-FED
LO2/CH4
SPLIT EXPANDER
RP-1
PRESSURE-FED
CRITERIA
SAFETY
ENVIRONMENT
RELIABILITY
SIMPLICITY
INTEGRATION
KSC
STS
PERFORMANCE
COST
RISK
DISCRIMINATORS
LOWEST IMPACT TO KSC
LOW DEVELOPMENT RISK
NO COMMON FUEL, ENGINE TO ALS
FUEL CREW IN PLACE
ESTABLISHED SAFETY PROCEDURES
LOW DEVELOPMENT RISK
POTENTIAL COST SPLIT WITH ALS
LESS FAMILIAR WITH FUEL
SAFETY CONCERNS
NO SIGNIFICANT
- COST
- PERFORMANCE
BENEFITS
DEVELOPMENT RISK
SPLIT EXPANDER
FEATURES
- LOW COST
- ALS OPTION
LO2/LH2 ENGINE OPTION
POTENTIAL LOW COST
HIGH DEVELOPMENT RISK DUE TO TECHNOLOGY REQUIREMENTS
ALTERNATE APPLICATIONS & GROWTH
CONTINUE TO REFINE
- SIZE
- COST
ALS
COMMON
- FUEL
- ENGINES
- TEST & DEVELOPMENT
STS
SHUTTLE "C"
STAND ALONE
CONTINUE OPTIMIZATION
- SYSTEM
- COST
TEST-BED ACTIVITY

LRB SELECTED CONFIGURATIONS

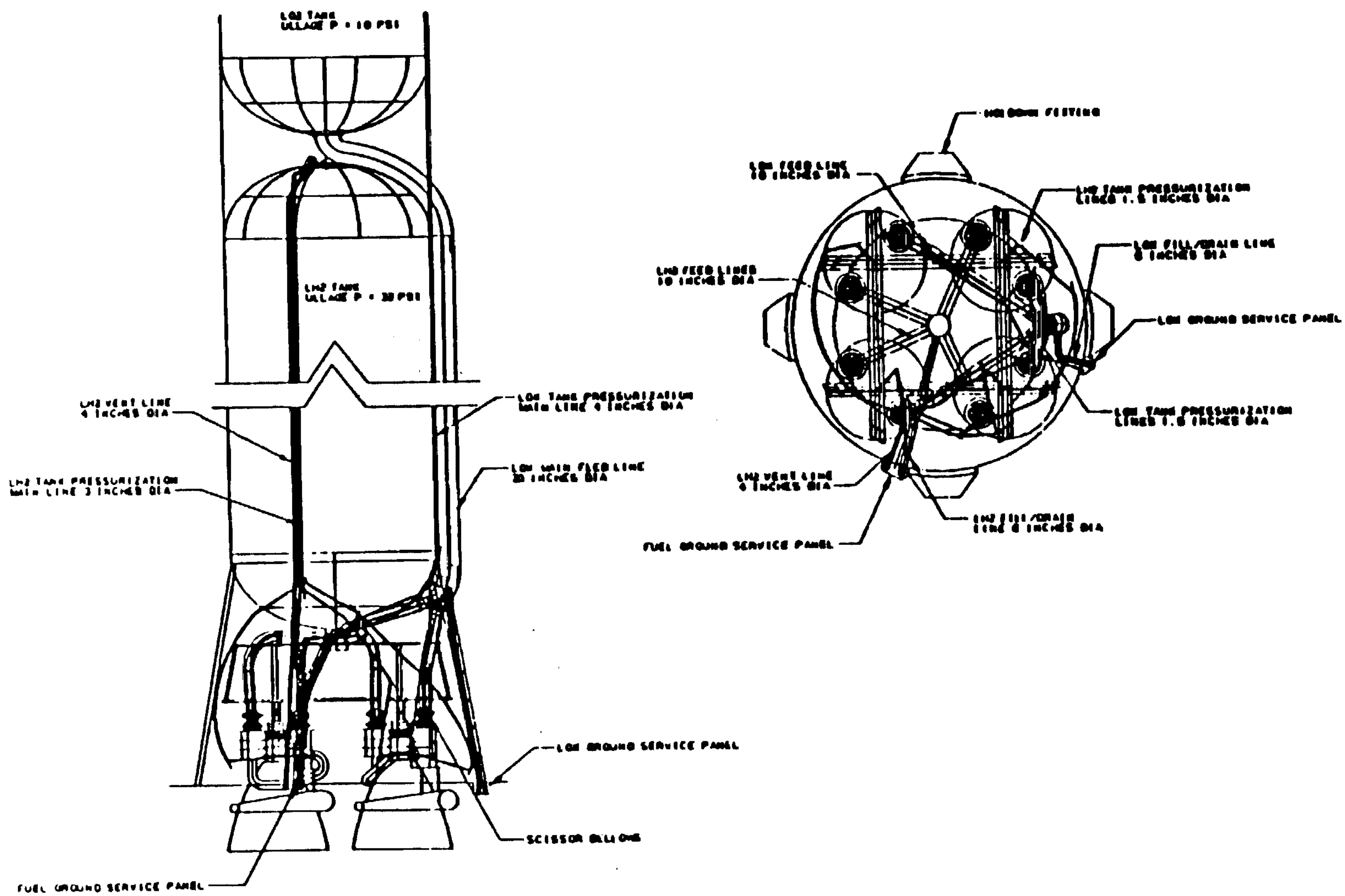
(GENERAL DYNAMICS)

o LOX/LH_2 CONFIGURATION INCORPORATES ON-BOARD 4-INCH GH_2 VENT LINE TO ROUTE VENTED GASES THROUGH LIFT-OFF UMBILICAL, AVOIDING THE NEED FOR NEW PAD VENT ARM.

LO2/LH2 PUMP-FED LRB
PROPULSION SYSTEMS

GENERAL DYNAMICS
Space Systems Division

LRB



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LRB PROPOSED ENGINE POSITIONS

- ALL GD CONFIGURATIONS (EXCEPT PRESSURE-FED) HAVE ENGINES POSITIONED AT 45-DEGREES TO THE MAJOR VEHICLE AXES ("X" PATTERN). THIS FACILITATES GIMBAL ACTUATORS ALONG THE PRIME PITCH AND YAW VEHICLE AXES, BUT REQUIRES A BRIDGE ACROSS THE BOOSTER FLAME HOLE TO SUPPORT THE NORTH HOLDDOWNS. THIS CONFIGURATION CONCENTRATES COMPLETE PRE-RELEASE TWANG LOADS ON ONLY TWO PAIRS OF HOLDDOWN POSTS.

- ALL MMC CONFIGURATIONS HAVE ENGINES POSITIONED ALONG OR PARALLEL TO THE MAJOR VEHICLE AXES ("+" PATTERN). THIS FEATURE PERMITS THE USE OF THE SAME HAUNCH/HOLDDOWN LOCATIONS CURRENTLY IN USE ALONG THE SIDES OF THE FLAME HOLES, BUT MOVES OUTERMOST ENGINE OUTSIDE THE EDGE OF FLAME TRENCH - COMPLICATING FLAME SIDE DEFLECTOR DESIGN.

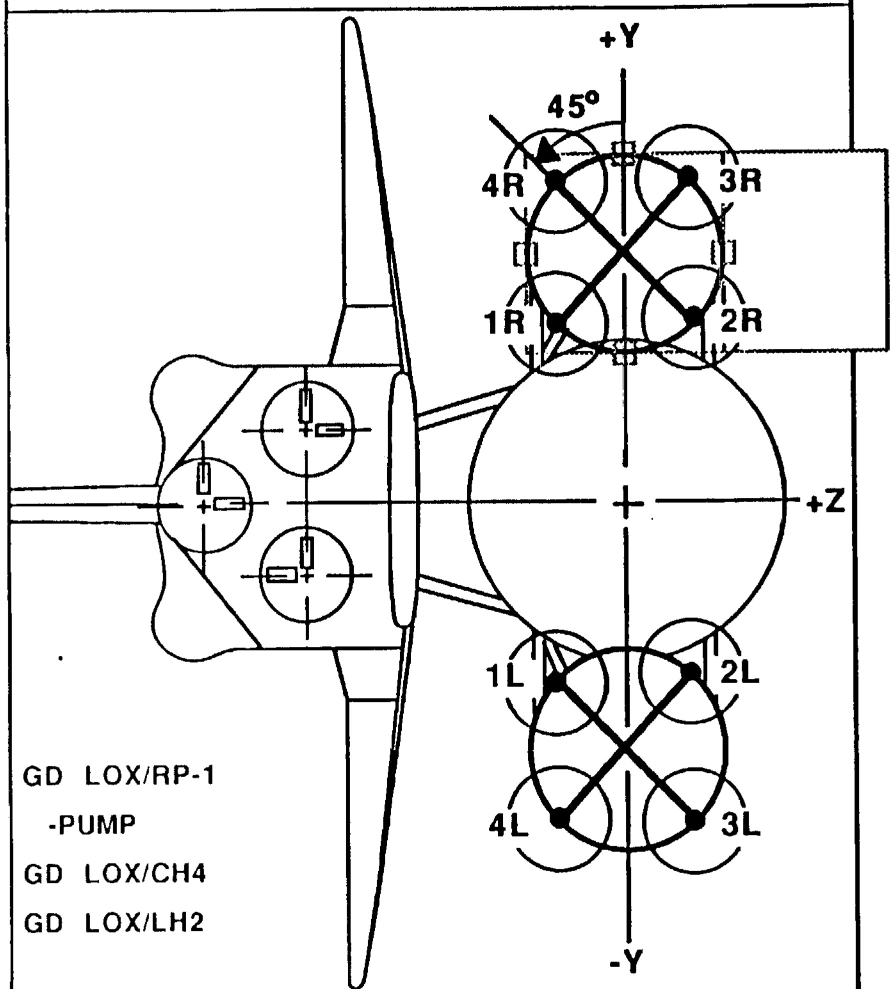
- GD PRESSURE-FED LOX/RP-1 HAS ENGINES POSITIONED IN THE "+" PATTERN (SAME AS MMC CONFIGURATIONS).

- ENGINE POSITION TRADE STUDIES SHOULD BE ANALYZED IN MORE DETAIL TO ESTABLISH BEST DESIGN APPROACH.

LRB PROPOSED ENGINE PROPORTIONS

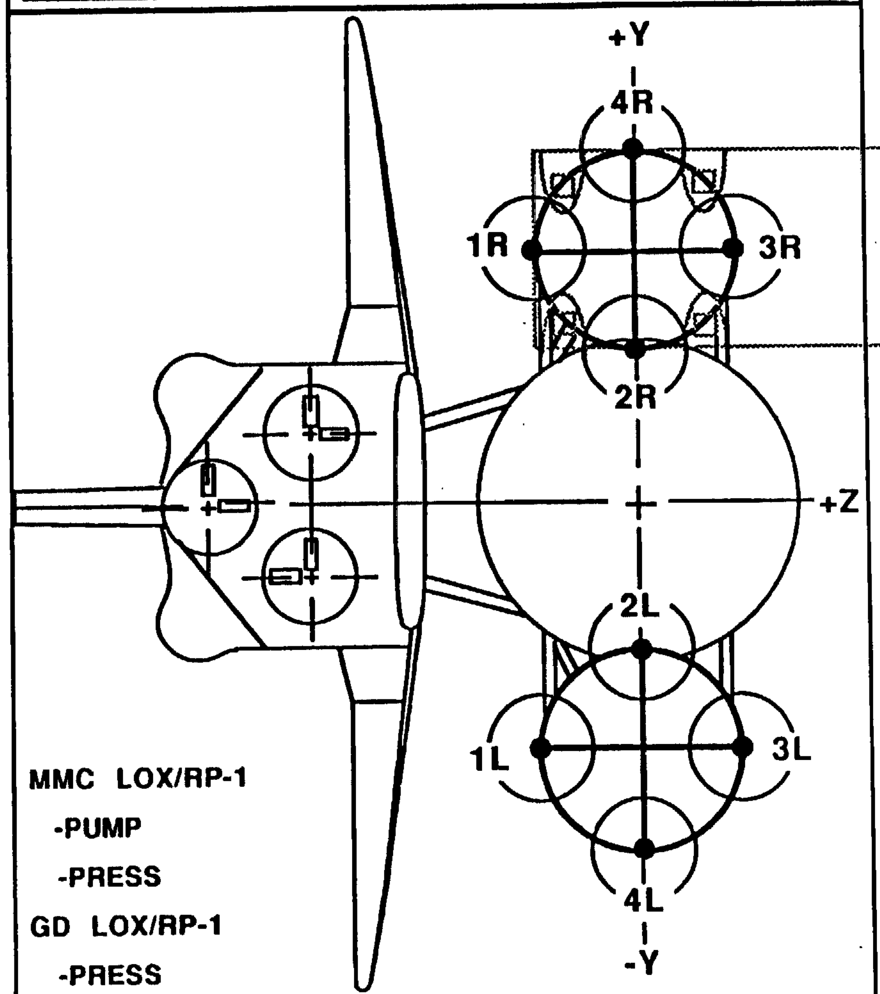
(VIEWS LOOKING FORWARD)

"X" PATTERN



GD LOX/RP-1
-PUMP
GD LOX/CH4
GD LOX/LH2

"+" PATTERN



MMC LOX/RP-1
-PUMP
-PRESS
GD LOX/RP-1
-PRESS

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LRB ENGINE DESIGNS

- PUMP-FED
- PRESSURE-FED
- SPLIT EXPANDER
- LRB ENGINE PROCESSING STUDY BY ROCKETDYNE
  - ENGINE SHOP/GSE/HANDLING
  - PRE-LAUNCH AND LAUNCH PROCEDURES, MANPOWER AND SCHEDULE

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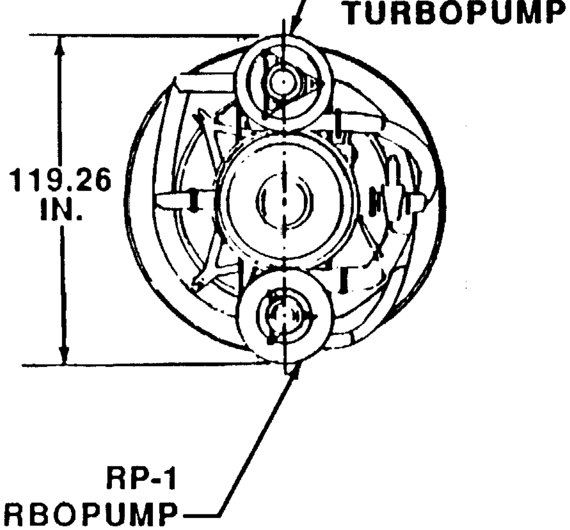
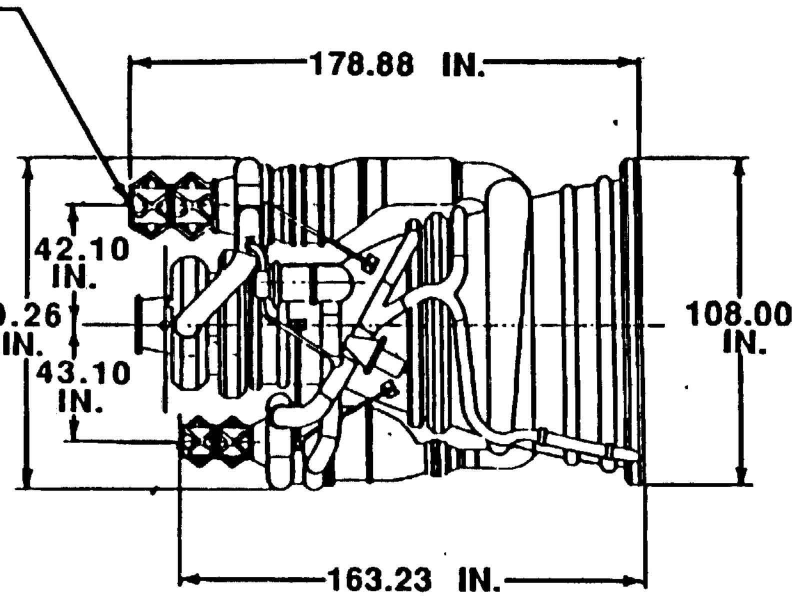
LRB LOX/RP-1 PUMP-FED ENGINE

GENERAL DYNAMICS
Space Systems Division



TOP VIEW



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Rocketdyne Division

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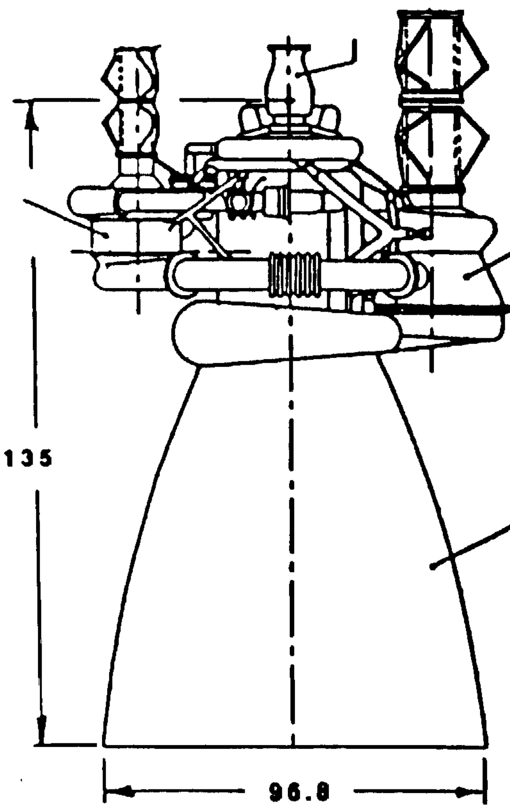
LRB PUMP-FED ENGINE
LO2/RP-1



	NPL	EPL
Thrust, S.L. klbs	513	685
Thrust, Vac. kbs	623	788
ISP, S.L. sec	265	277
ISP, Vac, sec	322	318
Mixture Ratio	2.6	2.5
Total Flow Rate, lb/sec	1933	2473
Chamber Pressure, Psia	1033	1300
Exit Pressure, Psia	5.9	7.7
Expansion Ratio	21.2	
Nozzle Type	Carbon-Carbon	
Weight, Dry, lbs	6807	
Engine Cycle	Gas Gen	
Propellants	LO2/RP1	
Gimbal Type	Head End	
Gimbal Angle	±6°	
Throttle Range	65 - 100%	

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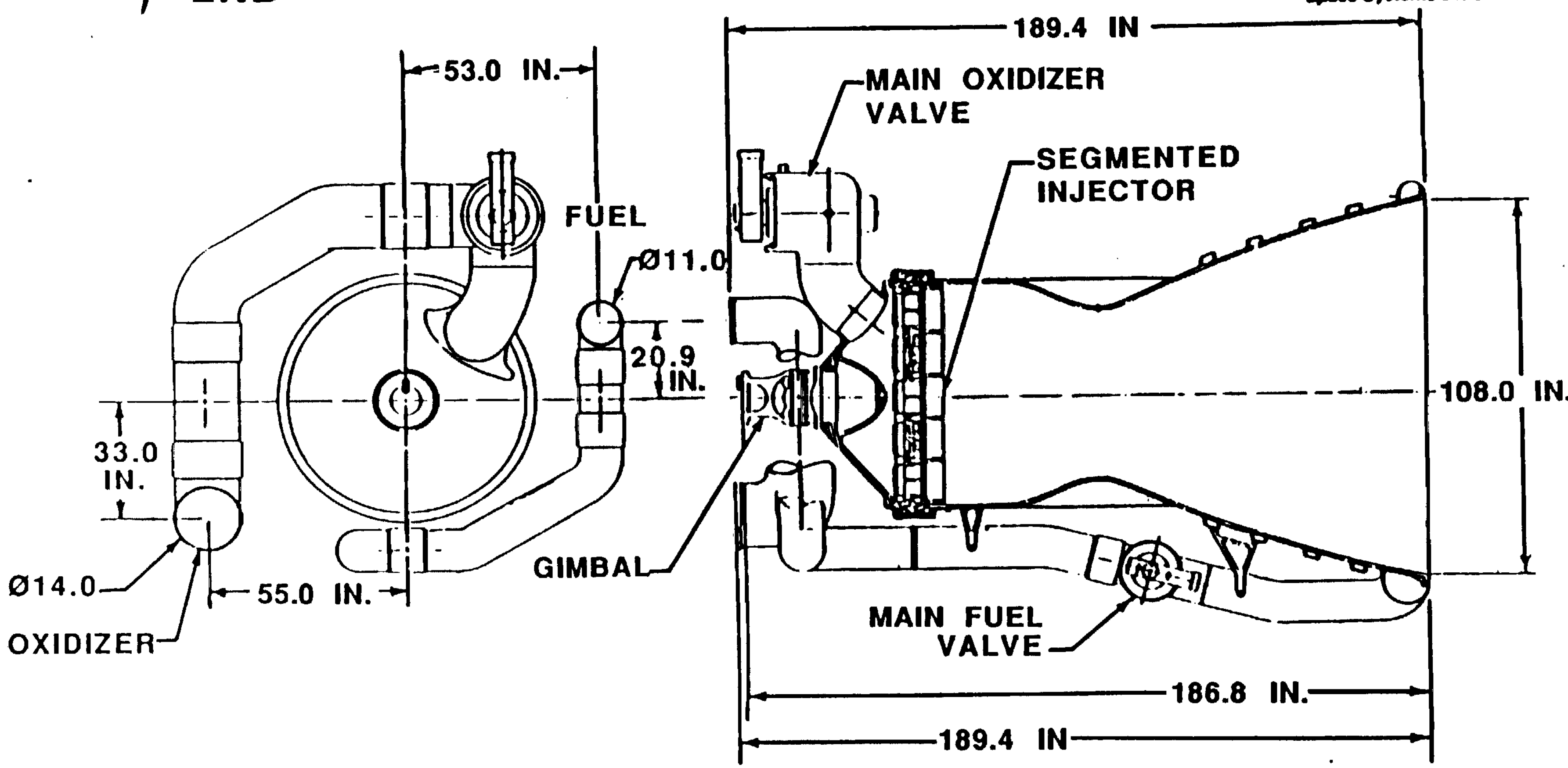
LRB PRESSURE- ːD LOX / RP-1 ENGINE

LRB

GENERAL DYNAMICS
Space Systems Division



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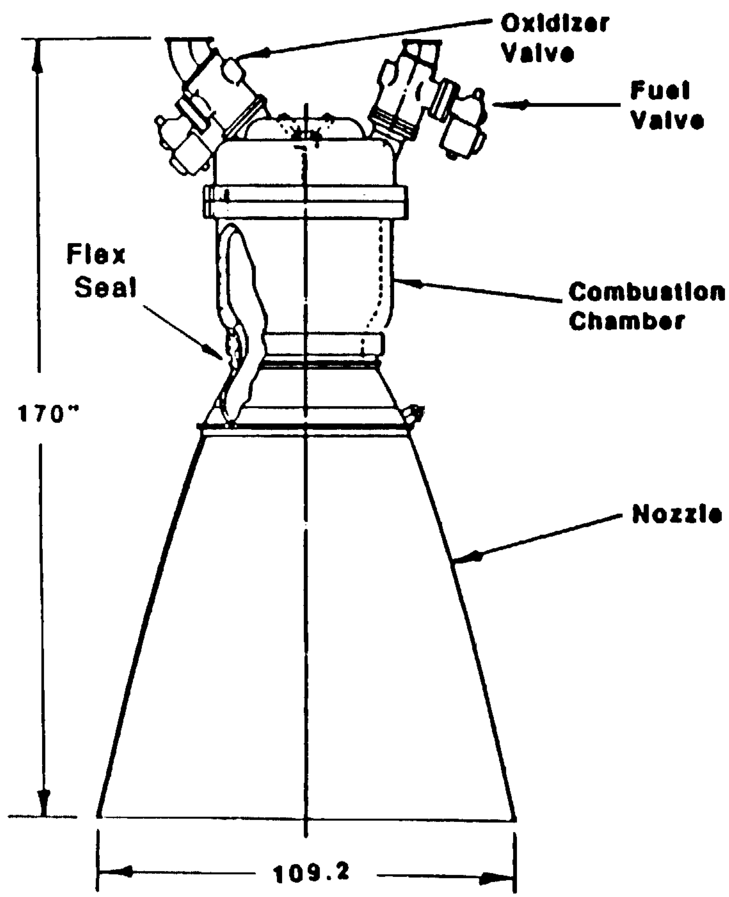
LRB PRESSURE FED ENGINE
LO2/RP-1



	NPL	FPL
Thrust, S.L. klbs	562	750
Thrust, Vac klbs	700	887
ISP, S.L. sec	257	271
ISP, Vac, sec	321	321
Mixture Ratio	2.7	2.7
Total Flow Rate, lb/sec	2185	2766
Chamber Pressure, Psia	630	800
Exit Pressure, Psia	5.5	6.9
Expansion Ratio	15.4	
Chamber Type	Ablative	
Nozzle Type	Ablative	
Weight, Dry, lbs	4500	
Propellants	LO2/RP1	
Gimbal Angle	±6°	
Gimbal Type	Head End Flex Seal (Optional)	
Throttle Range	65 - 100%	

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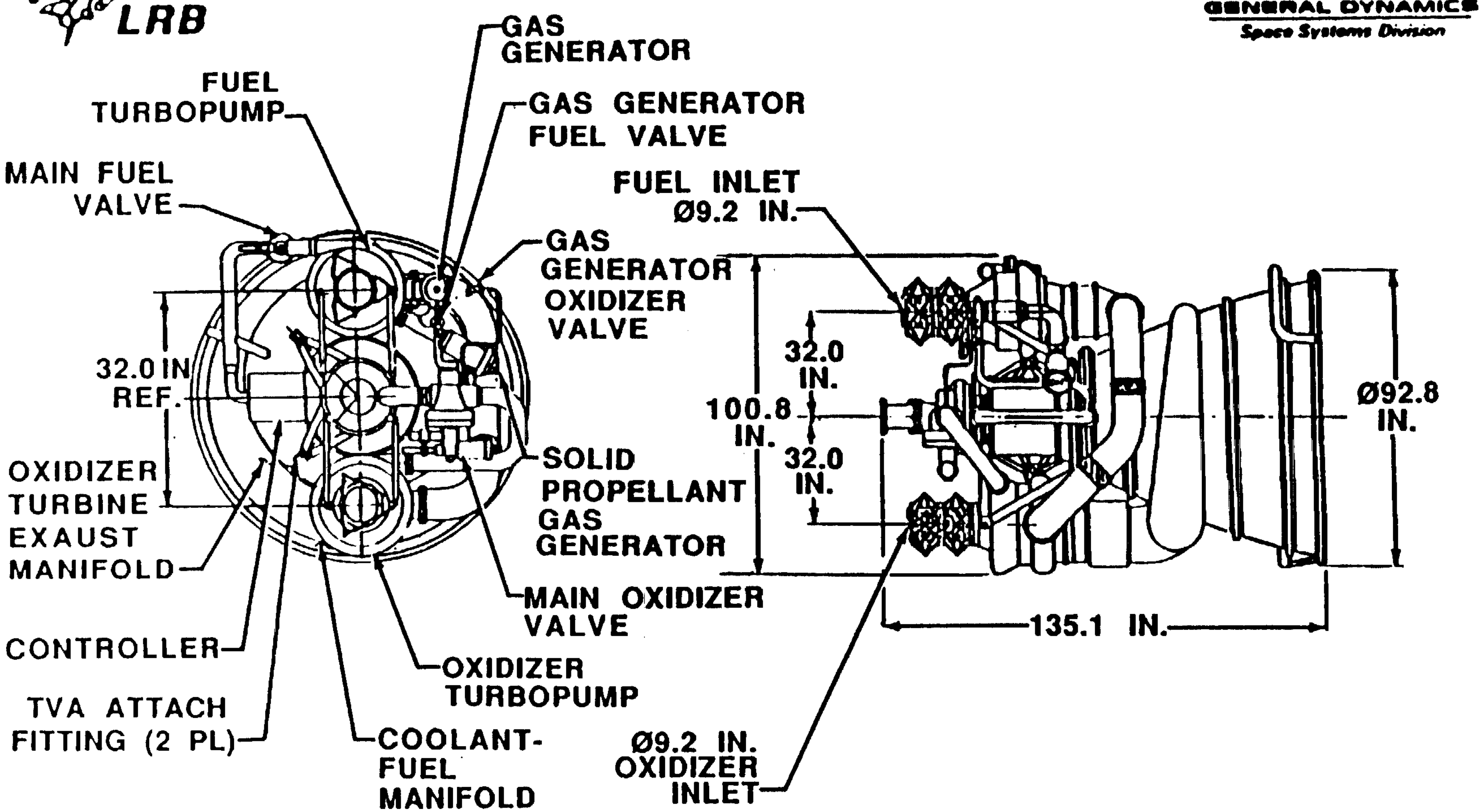
LRB LOX/H)ROGEN ENGINE

LRB

GENERAL DYNAMICS
Space Systems Division



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GENERAL DYNAMICS
Space Systems Division

LO2/LH2 PUMP-FED ENGINES FOR LRB

LRB

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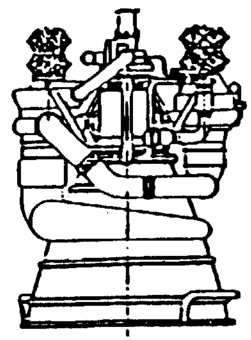
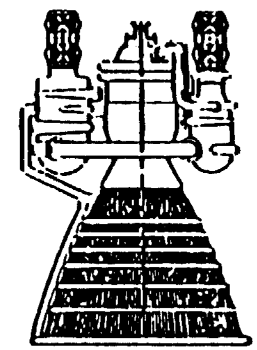


BASELINE



ALTERNATE

	BASELINE	ALTERNATE
• Engine Cycle	LO2/LH2 Gas Generator	LO2/LH2 Split Expander
• Thrust, vac EPL	612 klb	629 klb
• Weight	6,737 lb	5,089 lb
• Isp, sl/vac	374.1/426.3 sec	352.7/418.5 sec
• Mixture Ratio	6.0	6.0
• Area Ratio	40.1	16.2
• Pc, EPL	2538 psia	840 psia
• Throttling Capability	Continuous; 110% to 65%	Continuous; 100% to 65%
• Engine Control	Closed Loop	Closed Loop
• Min Inlet Pressure	LO2 - 65; LH2 - 25 psia	LO2 - 47; LH2 - 25 psia
• POGO Suppression	He Accumulator	He Accumulator
• Bleed Systems	Required	Required
• Boost Pumps	None	None
• Engine Reliability	0.99 @ 90% Confidence	0.99 @ 90% Confidence
• Risk Evaluation	Low; Cost Verification is needed	Technology & Low Cost Verification is needed

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DESIGN RECOMMENDATIONS

- LAUNCH SITE LRB DESIGN RECOMMENDATIONS
  - OPERATIONAL EFFICIENCIES
  - LAUNCH SITE CONSTRAINTS
- LRB DESIGN REQUIREMENTS ASSESSMENT
  - GROUND SYSTEMS IMPLICATIONS

LAUNCH SITE LRB DESIGN RECOMMENDATIONS

- A REPRESENTATIVE LIST OF RECOMMENDATIONS HAS BEEN PREPARED WHICH REFLECT LAUNCH SITE CONSTRAINTS AND IMPROVE OPERATIONAL EFFICIENCY. MANY, BUT NOT ALL, OF THESE HAVE BEEN INCORPORATED INTO THE PHASE-A LRB DESIGNS.

KSC-LRB DESIGN RECOMMENDATIONS

INCORPORATED DESIGN FEATURE	DESIGN RECOMMENDATIONS	INCORPORATED DESIGN FEATURE	DESIGN RECOMMENDATIONS
✓	• NO HYDRAULICS/NO HYDRAZINE	?	• MAKE BOOSTER AUTONOMOUS WITH MINIMUM ORBITER INTERFACES
✓	• USE LIFT-OFF UMBILICALS -NO SWING ARMS OR LUT	?	• USE SEPARATE BOOSTER DOWNLINK (RF)
1/2 ✓	• MAXIMUM LRB DIAMETER LESS THAN 16 FEET	✓	• FACILITATE SEPARATE LRB STANDALONE TEST AND CHECKOUT
?	• LOCATE AVIONICS LRU's IN AFT SKIRT AREA	✓	• ON BOARD LOX VENTS/NO BEANIE CAP
✓	• FACILITATE ENGINE R/R IN VERTICAL ON-MLP	(ALT)	• HARD MOUNTED ENGINES (NOZZLE GIMBALS FOR TVC)
✓	• USE EXPENDABLE DESIGN	✓	• MINIMIZE ET MODS
✓	• LOX/LH2 PROPELLANT HAS MINIMUM PAD IMPACTS	N.A.	• ELIMINATE ENGINE PURGES, BLEEDS AND SPECIAL PREPS
?	• NO FLAME TRENCH (CONCRETE) MODS AT PAD	N.A.	• CONSIDER EXTERNAL POD FOR AVIONICS AND BATTERIES TO FACILITATE ACCESS AND EASE OF SERVICE
✓	• FACILITATE VERTICAL AND HORIZONTAL CHECKOUT	✓	• AVOID ELEPHANT TRUNKS (TRAPS) IN PROPELLANT LINES THAT REQUIRE SPECIAL ATTENTION

LRB DESIGN REQUIREMENTS ASSESSMENT

- OUR STUDY TEAM REVIEWED THE PRELIMINARY LRB DESIGN REQUIREMENTS PUBLISHED IN GDSS FINAL REPORT. THE TOTAL RANGE OF REQUIREMENTS WAS REPRESENTED FROM TOP LEVEL GUIDELINES TO 4TH LEVEL SYSTEM REQUIREMENTS.

- ABOUT 70% (33 OUT OF 48) HAVE GROUND SYSTEM DESIGN IMPLICATIONS.

LRB DESIGN REQUIREMENTS ASSESSMENT

REF. GDSS

ITEM	TOTAL	NUMBER WITH GROUND SYSTEMS IMPLICATIONS
A. GUIDELINES GOALS, ASSUMPTIONS	12	11
B. LEVEL I REQUIREMENTS (SPACE TRANSPORTATION SYSTEM)	8	7
C. LEVEL II REQUIREMENTS (SPACE SHUTTLE VEHICLE)	8	4
D. LEVEL III REQUIREMENTS (LIQUID ROCKET BOOSTER)	11	9
E. LEVEL IV REQUIREMENTS (AVIONICS / FLT CONTROLS / SEPARATION SYSTEMS)	9	2
TOTALS	48	33

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DESIGN ISSUES

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SYSTEMS/DESIGN ISSUES

LRB DESIGN FEATURE	AFFECTED GROUND SYSTEM	DESIGN ISSUE
1. DIAMETER (13.9 TO 18.0 FT)	● MLP FLAME HOLES	● SIZE TO ACCOMMODATE (NEW MLP)
	● VAB PLATFORMS	● VEHICLE CLEARANCES
	● PAD FLAME TRENCH	● CONCRETE MODS & C/T TRACK WIDTH
	● FLAME DEFLECTORS	● DESIGN ANGLES / PLUME IMPINGEMENT
	● ET GH2 VENT	● VEHICLE LIFT-OFF CLEARANCE
2. LENGTH (147 TO 197 FT)	● VAB PLATFORMS	● ACCESS AT HIGHER LEVELS
	● GOX VENT ARM	● 170 FT LENGTH LIMIT FOR CLEARANCE
	● TRANSPORTER/BARGE AND PROCESS FACILITY	● SIZE TO ACCOMMODATE
	● VAB DIAPHRAGM	● LIFT OVER HEIGHT LIMITS BOOSTER LENGTH TO 200 FT
	● PAD ACCESS / FWD	● LENGTHS ABOVE 150 FT REQUIRE SIGNIFICANT NEW CONSTRUCTION

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SYSTEMS/DESIGN ISSUES

LRB DESIGN FEATURE	AFFECTED GROUND SYSTEM	DESIGN ISSUE
3. ENGINE POSITIONS ("+" OR "X" PATTERNS)	• MLP HOLDDOWN SYSTEM AND FLAME HOLES • PAD FLAME TRENCH AND DEFLECTORS	• HOLDDOWNS BETWEEN ENGINES FORCE FLAME HOLE BRIDGE FOR "X" PATTERN AND CONCENTRATES TWANG LOADS ON TWO HD POSTS • "+" PATTERN FORCES OUTBOARD ENGINES OUT OF FLAME TRENCH
4. BOOSTER BENDING STIFFNESS (FIRST MODE FREQUENCY) IGNITION SEQUENCE, LAUNCH LOADS	• ALL GROUND INTERFACES AT PAD • T-0 UMBILICALS	• STATIC / DYNAMIC EXCURSIONS UNDER ALL PRE-LAUNCH AND SHUTDOWN LOAD CONDITIONS / TRACKING REQMTS • TWANG DEFLECTIONS AT T-O, UMBILICAL TRACKING ABILITY, LRB / SSME IGNITION SEQUENCE • MLP STIFFNESS AND HD DESIGN
5. CRYO VENTING	• SWING ARMS FOR VENTS TO PREVENT ICE FORMATION	• ON-BOARD NON-ICING GOX VENTS VS NEW SWING ARMS, GH2 VENTS ROUTED TO LIFT-OFF UMBILICALS VS NEW SWING ARMS
6. LRB ENGINE THRUST BUILDUP, POGO SUPPRESSION AND LAUNCH LOADS	• HOLDDOWN SYSTEM, SOFT RELEASE • SIDE AND MAIN DEFLECTORS	• THRUST BUILDUP TIME AND HEALTH CHECKS REQUIRE NEW HD SYSTEM DESIGN TO REACT FULL VEHICLE THRUST PRIOR TO SOFT RELEASE / DEFLECTOR REDESIGN REQUIRED

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SYSTEMS/DESIGN ISSUES

LRB DESIGN FEATURE	AFFECTED GROUND SYSTEM	DESIGN ISSUE
7. LRB/STS THRUST-TO-WEIGHT RATIO, ENGINE-TVC CONTROL	• LIFT-OFF CLEARANCES DRIFT AND PAD STRUCTURES	• VEHICLE SIZE AND DRIFT UNDER NOMINAL AND ENGINE-OUT CONDITIONS, PAD UMBILICALS AND HARD STRUCTURE DESIGN CLEARANCES
8. LRB INSTRUMENTATION FLIGHT AND LPS SOFT-WARE INTERFACES	• LPS, CHECKOUT AND TERMINAL LAUNCH COUNT MODES (GROUND SOFTWARE DESIGN)	• GROUND S/W CHECKOUT, STANDALONE AND INTEGRATED. LPS PROPELLANT LOADING, INSTRUMENTATION AND LAUNCH OPS.
9. LRB/ET AND ORBITER INTERFACES	• INTERFACE VERIFICATION PROCEDURES (MECHANICAL AND ELECTRICAL)	• COMMON ET AND ORBITER INTERFACE DESIGN REQUIRED TO AVOID NON-STANDARD PROCEDURES AND STS MODIFICATIONS • LRB TELEMETRY REQUIREMENTS
10. PROPELLANT LOADING	• GROUND UMBILICALS AND MLP/PAD PROPELLANT SYSTEMS	• LIFT-OFF UMBILICALS VS NEW SWING ARMS, LUT APPROACH

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SYSTEMS/DESIGN ISSUES

LRB DESIGN FEATURE	AFFECTED GROUND SYSTEM	DESIGN ISSUE
11. LRB ENGINE TVC DESIGN	● CHECKOUT GSE AND PROCEDURES	● ELECTRO-MECHANICAL CHECKOUT AND GSE VS HYDRAULICS AND HPU HYDRAZINE PROCEDURES / GSE. GROUND ELECTRICAL PROVISIONS FOR TVC CHECKOUT
12. LRB ENGINE DESIGN APPROACH	● CHECKOUT GSE AND PROCEDURES	● ENGINE PURGES, BLEEDS AND SPECIAL CONDITIONING VS SIMPLIFIED, "ROBUST" ENGINE DESIGN W/AUTOMATED DIAGNOSTICS
13. ENGINE LRU DESIGN	● GROUND HANDLING GSE AND PROCEDURES	● MODULARIZED ENGINE-LEVEL LRU PLUS SHOP SERVICE VS INVOLVED LRU R/R IN-PLACE ON VEHICLE
14. LRB DESIGN FOR HORIZONTAL PROCESSING	● GROUND HANDLING, CRANE LIFTING OPERATIONS/ PROCEDURES	● VERTICAL CHECKOUT AND LIFTING OPERATIONS VS HORIZONTAL SERVICING ON TRANSPORTER AND SINGLE ROTATION AND LIFT TO MATE MLP
15. LRB PRESSURIZED TANKS	● GSE FOR PRESSURIZING ON-BOARD SYSTEMS, AND LEAK CHECK PROCEDURES AND GSE FOR CHECKOUT	● NEW GROUND PRESSURIZATION SYSTEMS AND PROCEDURES VS TURBOPUMP CHECKOUTS FOR PUMP-FED SYSTEMS

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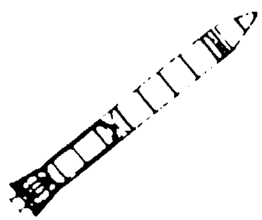
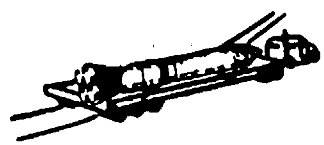
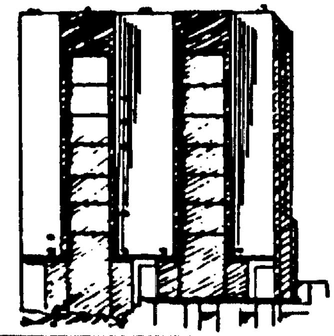
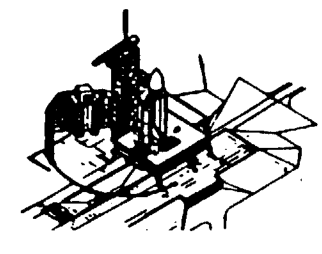
LAUNCH SITE SCENARIO

- LRB PROCESSING REQUIREMENTS
- KSC / STS BASELINE MODEL
    - SRB PROCESSING
- LRB SCENARIO
    - PROCESSING TIMELINES
    - STANDALONE / INTEGRATED TASKS
- SRB / LRB COMPARISON
- LRB LAUNCH SITE PLAN
- KEY LRBI STUDY FINDINGS

LRB PROCESSING REQUIREMENTS CHECKLIST

- OUR STUDY TEAM DRAFTED A "KSC REQUIREMENTS CHECKLIST" EARLY IN THE STUDY AND CIRCULATED IT TO BOTH GDSS AND MMC STUDY TEAMS. THE CHECKLIST WAS ORGANIZED INTO A QUESTIONNAIRE FORMAT DEALING WITH THESE MAJOR AREAS OF PROCESSING ACTIVITIES AND SYSTEMS.
- PESPONSES WERE RECEIVED AND COORDINATED WITH BOTH CONTRACTORS AND ARE INCLUDED IN OUR FINAL REPORT.
- THE REQUIREMENTS CHECKLIST PROMOTED DISCUSSIONS AND DESIGN RECOMMENDATIONS FOR LRB LAUNCH SITE OPERATIONAL EFFICIENCIES.

LRB PROCESSING REQUIREMENTS CHECKLIST

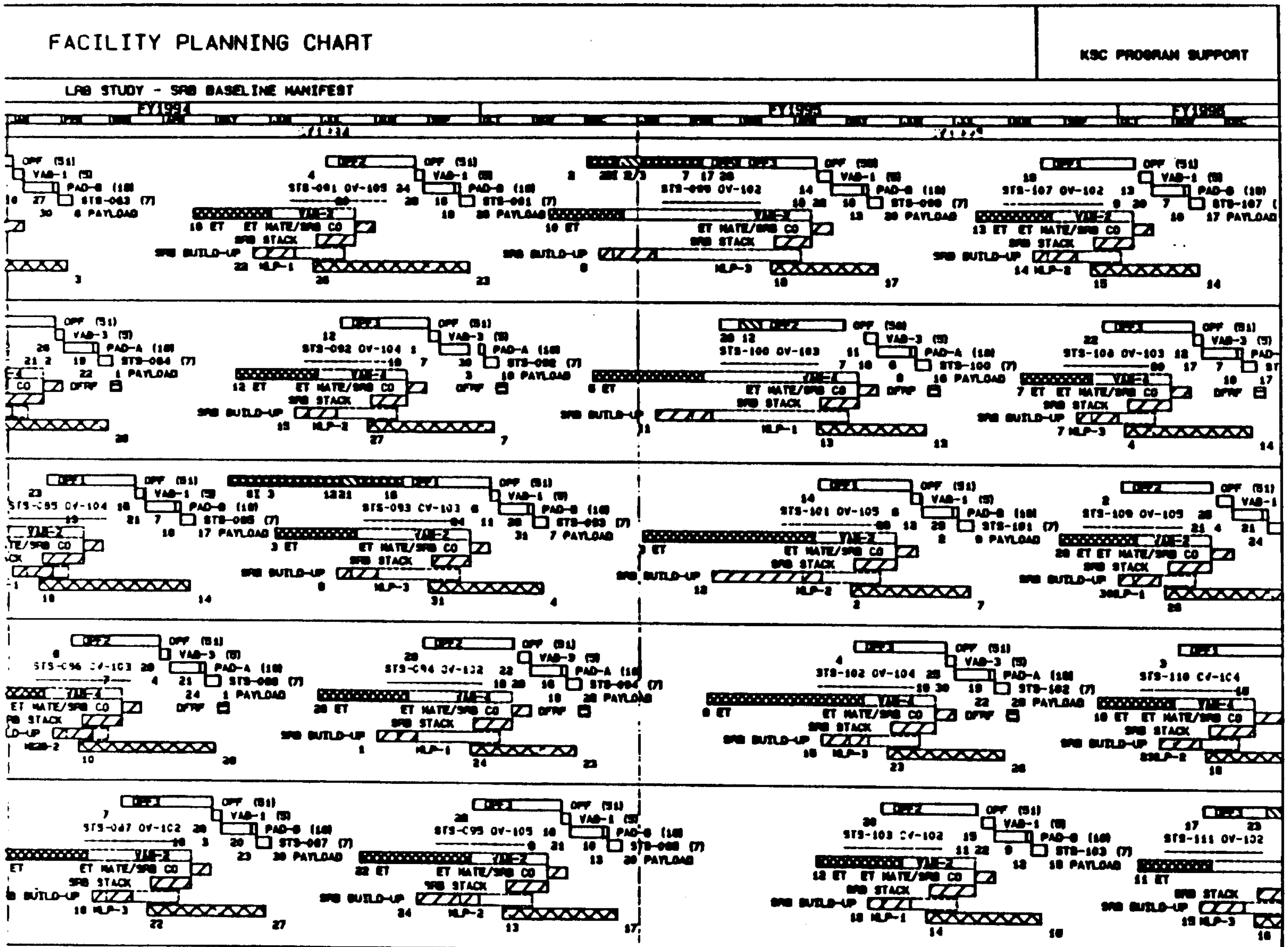





PROPERTIES	GENERAL REQUIREMENTS	SYSTEM-SPECIFIC REQUIREMENTS
• BOOSTER PROPERTIES —PUMP-FED —PRESSURE-FED —SPLIT EXPANDER • PROPELLANTS —LOX / RP-1 —LOX / LH2	• CONFIGURATION DATA • EQUIPMENT DESCRIPTIONS • OPERATING CRITERIA • INTERFACE REQUIREMENTS • LAUNCH SITE CONSTRAINTS • HANDLING REQUIREMENTS	• RECEIVING / HANDLING • ASSEMBLY / PROCESSING • INTEGRATION • SAFETY / ENVIRONMENTAL • SPARES / LOGISTICS • TEST / CHECKOUT • PRE-LAUNCH • GROUND SOFTWARE • LAUNCH OPS • ABORT / SCRUB • RECOVERY • REFURBISHMENT

STS BASELINE MODEL

- MULTI-FLOW PROCESSING TIMELINES HAVE BEEN DEVELOPED FOR STS LAUNCHES 1991 THRU 2006 (ARTEMIS MODEL)
- THIS SCHEDULE REPRESENTS THE STS TRANSITION FROM NEAR TERM MANIFEST (MAR 88) TO LONG RANGE LAUNCH RATE OF 14/15 PER YEAR
- FACILITY UTILIZATION DIAGRAMS PRESENT WINDOWS FOR SCHEDULING LRB FACILITY MODS/ACTIVATION ACTIVITIES
- PLANNING LAYOUTS FOR ACTIVATION/TRANSITION/OPERATIONS PHASES WERE PREPARED TO ACHIEVE LRB IMPLEMENTATION
- MINIMUM IMPACTS TO ON-GOING LAUNCH OPERATIONS CAN BE ACHIEVED USING THIS PLANNING TOOL THROUGHOUT THE INTEGRATION ACTIVITIES, ACCOMMODATING SCHEDULE AND MANIFEST CHANGES AS THEY (MOST ASSUREDLY WILL) OCCUR.

ARTEMIS STS BASELINE MODEL



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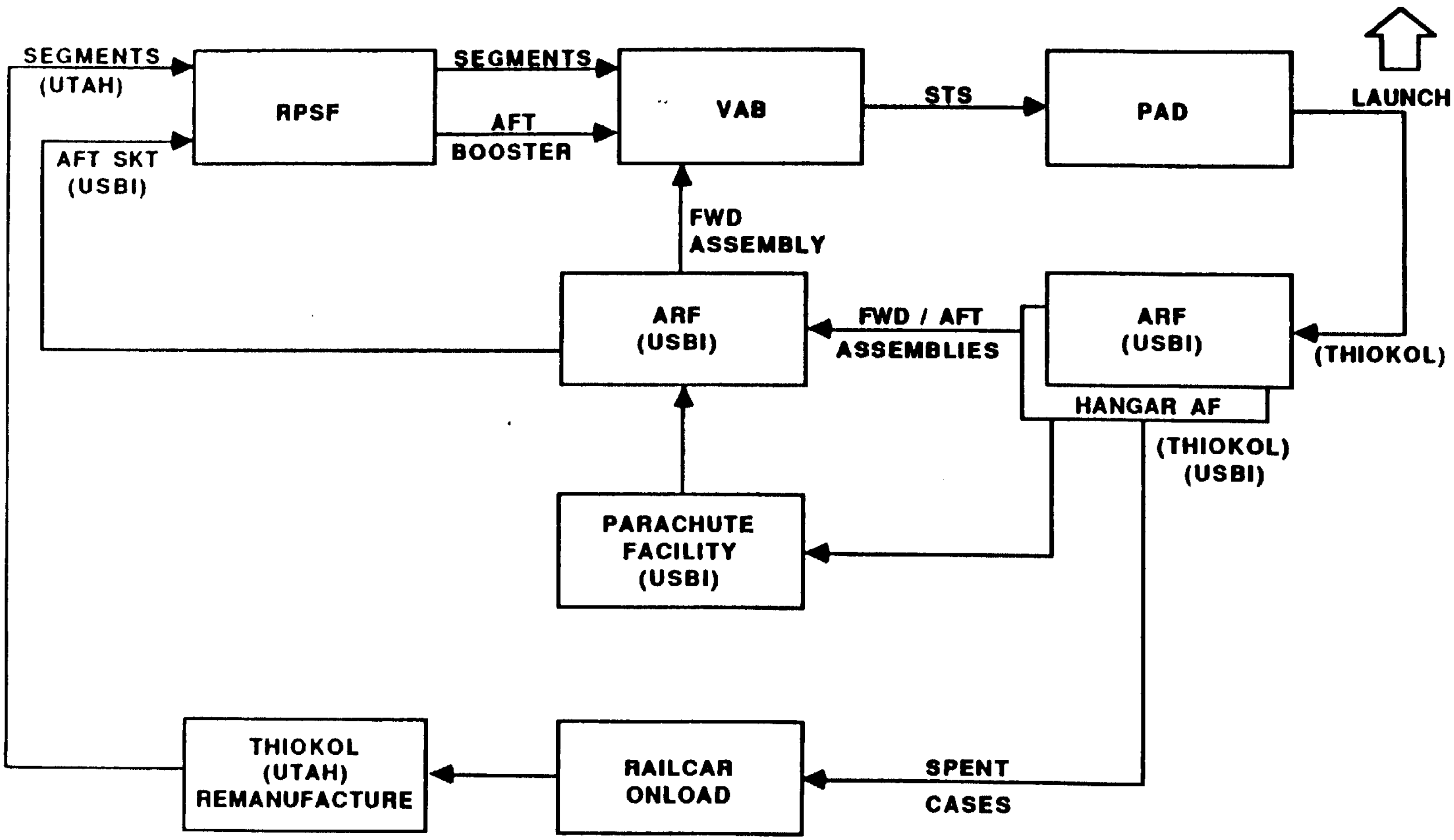
BASELINE SRB PROCESSING



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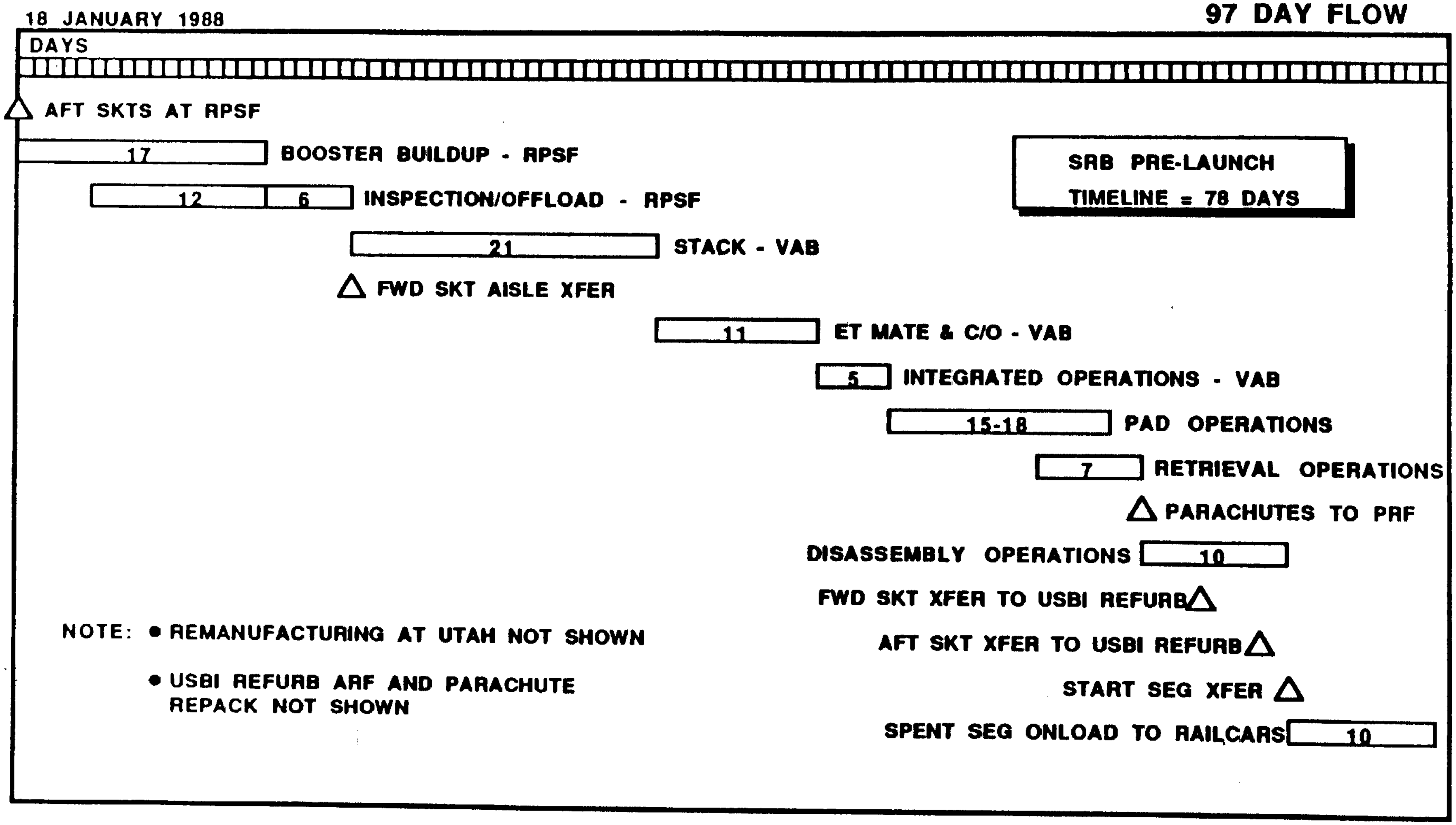
1994 SRB PROCESSING BASELINE SUMMARY



LRB PROCESSING SUMMARY

THE LRB PROCESSING SCENARIO BEGINS AT KSC WITH BARGE DELIVERY, AND HORIZONAL TRANSPORTER TOW TO THE NEW LRB PROCESSING FACILITY. HERE ALL STANDALONE BOOSTER CHECKOUT AND TESTING IS CONDUCTED. THE ADJACENT ET HORIZONAL PROCESSING FACILITY RELOCATES THE ET CHECKOUT AND STORAGE ACTIVITY SO THAT HB4 CAN BE USED.

THE CONVERSION OF VAB/HB4 TO A FULL INTEGRATION CELL PERMITS LRB TRANSITION WITHOUT IMPACT TO ON-GOING SHUTTLE LAUNCHES. A NEW MLP CUSTOM-BUILT FOR LRB WILL BE CONSTRUCTED TO SUPPORT THE LRB IOC, AND A SECOND NEW MLP IS NOW SCHEDULED TO SUPPORT THE LRB TRANSITION LAUNCH RATE BUILD-UP. THIS APPROACH REPLACES THE EARLIER PLANNED MODIFICATION OF EXISTING MLP's.

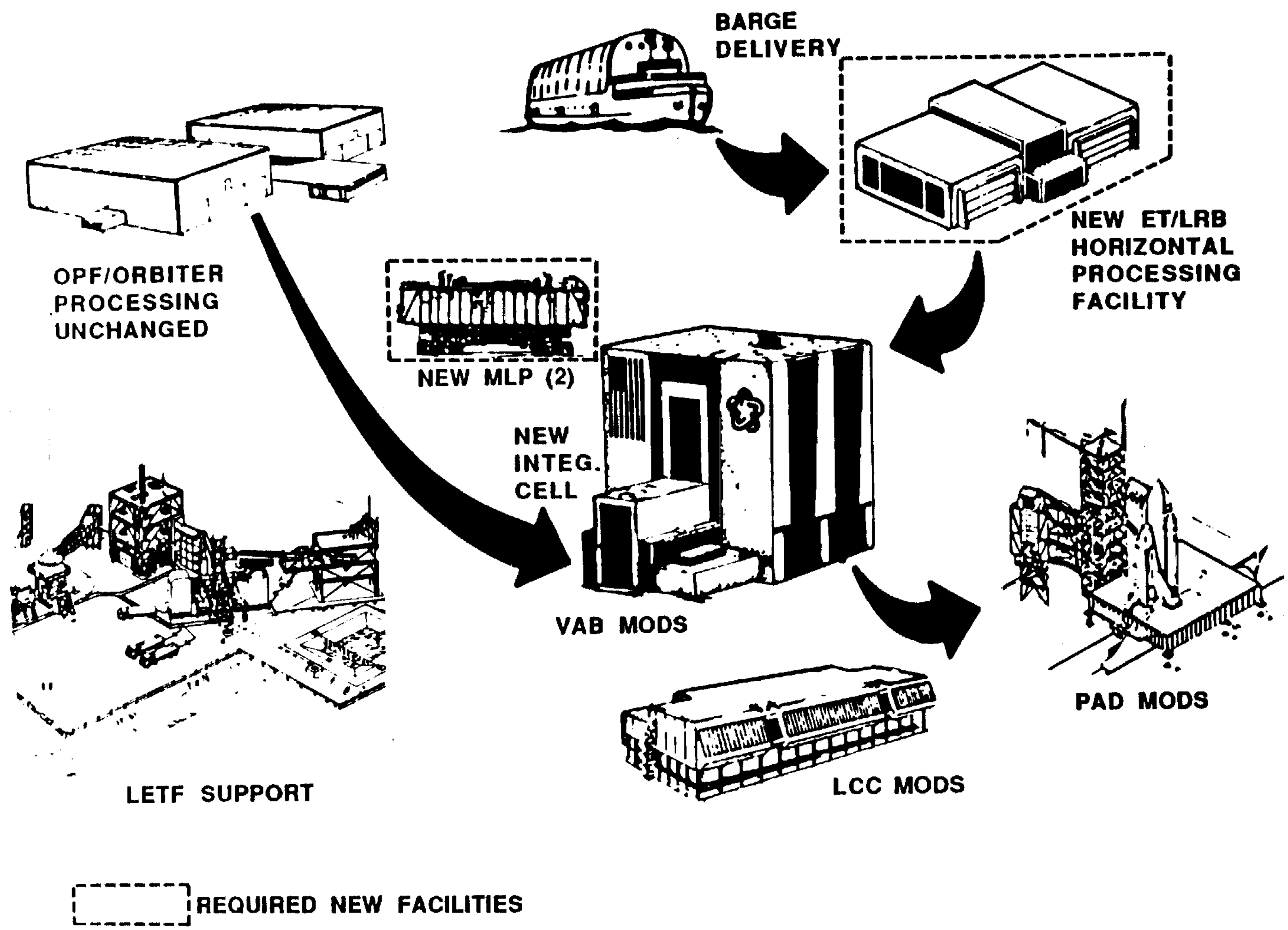
THE LAUNCH CONTROL CENTER FIRING ROOMS WILL BE MODIFIED TO SUPPORT ANY NEW CONSOLES AND GROUND SOFTWARE REQUIRED FOR LRB PROCESSING AND LAUNCH OPERATIONS. LETF SUPPORT FOR THE NEW MLP/PAD LSE QUALIFICATION/CERTIFICATION TESTING IS PLANNED.

- SECOND NEW MLP DUE TO: 1) DIFFICULTY OF MOD AND 2) IMPACT TO SRB LAUNCHES

- NEW MORE EXTENSIVE PAD MODS:
  1) DEFLECTOR REDESIGN IN FLAME TRENCH
  2) SIDE DEFLECTOR (PROXIMITY REQUIREMENTS)
  3) <u>POSSIBLE</u> FLAME TRENCH MODS

Lockheed Space Operations Company

PRELIMINARY L..B SCENARIO



GENERIC LRB PROCESS FLOW

- A DETAILED PROCESSING ASSESSMENT OF THE LRB REQUIREMENTS WAS PERFORMED WHICH RESULTED IN THE DEVELOPMENT OF A 130-TASK LRB FLOW SCHEDULE. THIS SCHEDULE INCLUDES STANDALONE CHECKOUT AND TESTING, MLP MATE AND ET/LRB MATE/CLOSEOUT, ORBITER INTEGRATION/TEST AND PAD OPERATIONS.

- A TOTAL LRB FLOW TIME OF 58 DAYS IS PRESENTED HERE AS THE "GENERIC" PROCESS FLOW TIME. THE SCHEDULE IS ANTICIPATED TO BE ACHIEVED ON THE 4TH LRB LAUNCH PROCESSING FLOW KNOWN AS THE INITIAL OPERATIONAL CAPABILITY (IOC)

- THIS MODEL IS NETWORKED IN ARTEMIS WHERE HANDS-ON MANPOWER AND SHIFT DURATIONS FOR EACH TASK ARE DISPLAYED. INTEGRATION WITH MAJOR STS ACTIVITIES AND MILESTONES HAS BEEN ACHIEVED.

GENERIC LRB PROCESS FLOW

LRB FLOW = 58 DAYS

▲ LRB BARGE ON DOCK KSC

18 — LRB STANDALONE CHECKOUT (5/3)

- OFFLOAD/TRANS TO HPF
- REC/INSP
- SYS FUNCT CHECKOUTS
- ENGINE/PROP SYS LEAK & FUNCTIONAL

▲ LRB MOVE TO VAB

4 — MLP MATE & CLOSEOUTS (7/3)

▲ ET MATE

11 — ET/LRB CLOSEOUTS (7/3)

▲ 5 — ORB MATE/INTEG SYS TEST (7/3)

SSV PREPS/TRANSFER TO PAD ▲

20 — LAUNCH (6/3)

- SSV STD OPS
- PAYLOAD OPS
- CDDT
- LRB ENG SYS READINESS
- LRB FUEL (RP) TANKING
- ORB HYPER LOAD/CLOSEOUT
- LAUNCH COUNTDOWN (INCLUDING CRYO LOAD)

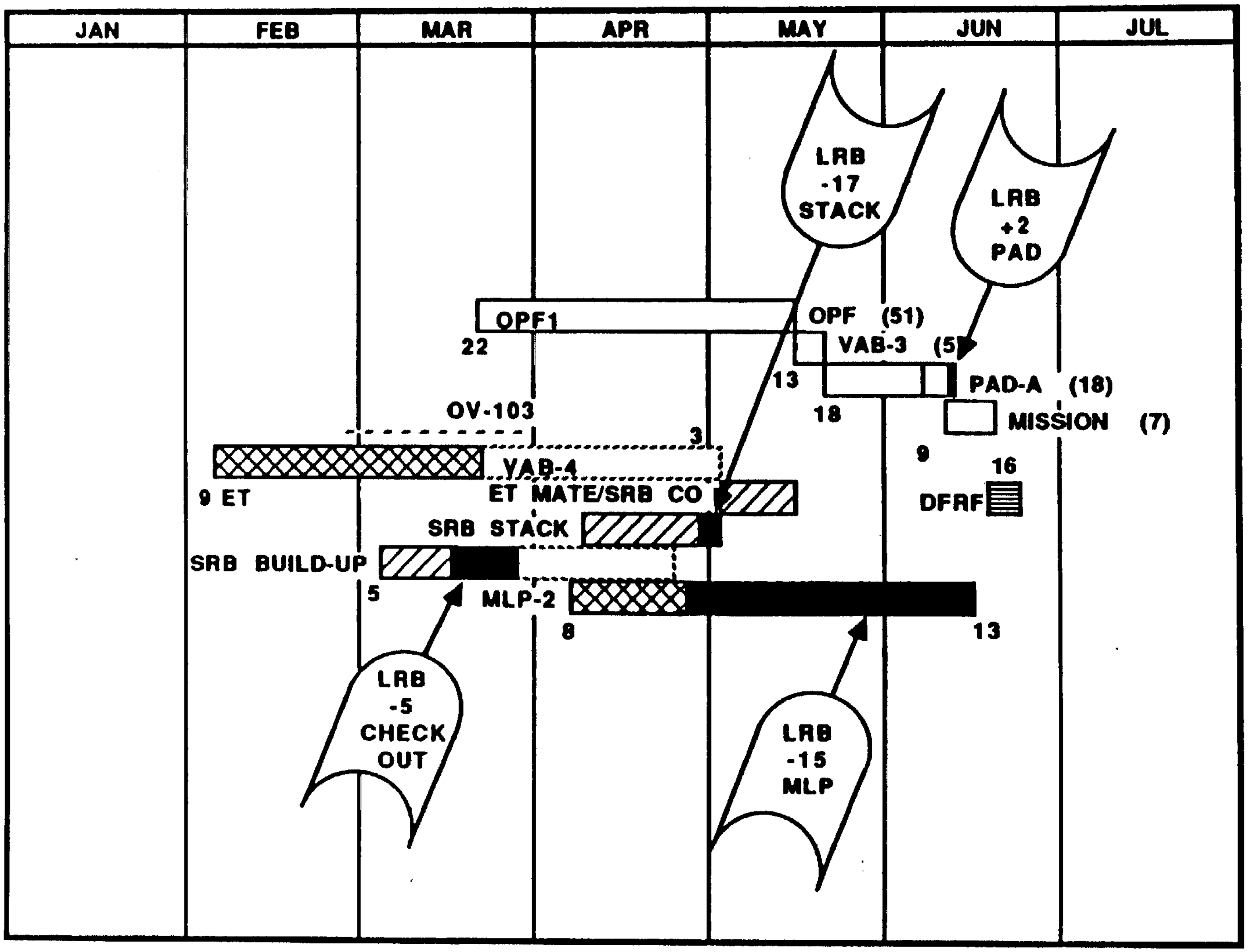
LRB/SRB FACILITY PLANNING COMPARISON

- GRAPHICALLY NOTED HERE ARE THE FLOW TIME DIFFERENCES FOR LRB (SHOWN SOLID BLACK) ON THE BACKDROP OF PLANNED SRB FLOW PROCESSING TIMELINES IN THE MID-TO-LATE 90's.

- ALL IN-LINE GROUND PROCESSING TO SUPPORT AN EXAMPLE FLOW IS PRESENTED. NOTE MAJOR FACILITIES AND ELEMENTS. THE LRB "DELTAS" ARE SHOWN IN THE BOXES FOR THE FOUR MAJOR AFFECTED FUNCTIONS.

- THE ARTEMIS MULTIFLOW PROCESSING MODEL CONTAINS 224 MISSIONS OF THIS DETAIL OVER THE PERIOD FY91 THRU FY06. INSERTION OF THE 122-MISSION LRB LIFE CYCLE PROFILE INTO THIS MODEL WILL FACILITATE EFFECTIVE PLANNING FOR KSC INTEGRATION.

LRB/SRB FACILITY PLANNING COMPARISON



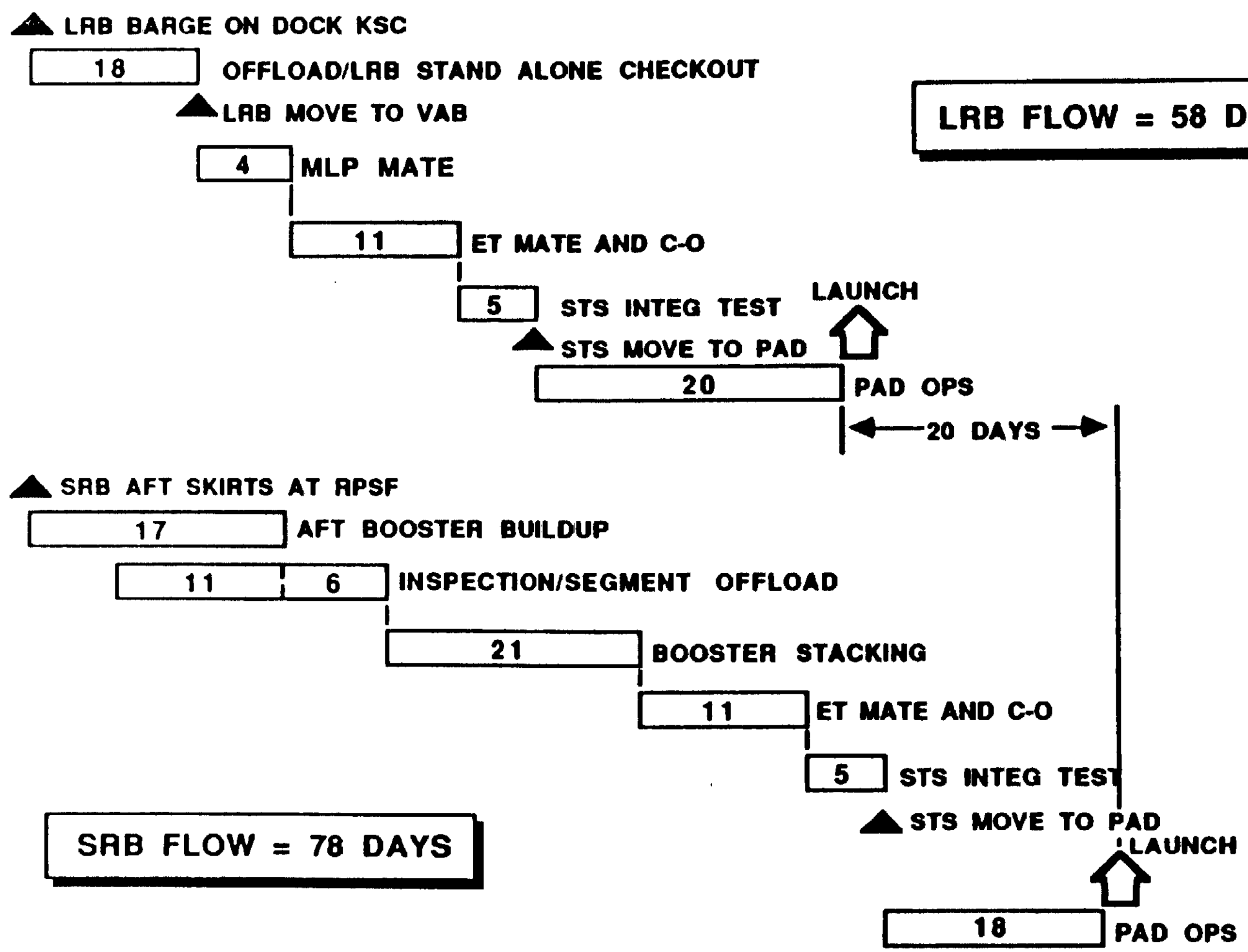
GENERIC LRB/SRB PROCESS FLOW COMPARISON

- THE LRB FLOW FROM RECEIPT OF HARDWARE TO LAUNCH IS HERE COMPARED WITH THE LATE 90's FORECASTED SRB TIMELINE.

- A TOTAL OF 20 DAYS IS SAVED IN THE LRB ACTIVITIES DUE TO THE LENGTHY STACK TIME FOR SRB. THIS STACK TIME ESTIMATE VARIES FROM 21 TO 24 DAYS. STS-26R STACK TIME WAS ABOUT 65 DAYS.

- THIS IMPROVED FLOW TIME FOR LRB RESULTS IN LOWER DEMAND ON LAUNCH SITE RESOURCES FOR THE SAME SUSTAINED STS FLIGHT RATE.

GENERIC LRB/SRB PROCESS FLOW COMPARISON



NOTE: SRB RETRIEVAL, DISASSEMBLY, REFURBISHMENT AND REMANUFACTURING ARE NOT SHOWN.

SRB/LRB FLOW COMPARISON

- o SUMMARIZED HERE ARE THE PROJECTED IMPROVEMENTS IN FLOW TIME FOR LRB VERSUS THE "PLANNED" SRB PROCESSING TIMES FORECAST FOR THE LATE 90's.

- o THESE IMPROVEMENTS REPRESENT A SIGNIFICANT REDUCTION IN DEMAND ON LAUNCH SITE RESOURCES REQUIRED TO SUPPORT A 14 TO 15 ANNUAL LAUNCH RATE - AND THEY PROVIDE THE FLEXIBILITY TO ACCOMMODATE ALTERNATE SHUTTLE "C" OR ALS LAUNCH CAPABILITIES.

SRB / LRB FLOW COMPARISON

	WORK DAYS		% REDUCTION
	SRB	LRB	
VAB HB (INTEG CELL)	21	4	81%
MLP USE PER FLOW	55	40	27%
INTEG CRITICAL PATH (BOOSTER STACK TO ORB MATE)	32	15	53%
PAD FLOW	18	20	-11%
BOOSTER FLOW (PRE-LAUNCH)	78	58	25%

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LAUNCH SITE PLAN

- KSC
  - PHASED PLANNING
  - TRANSITION ENVIRONMENT
  - DEFINED IMPACTS
- VLS
  - SUMMARY SCENARIO

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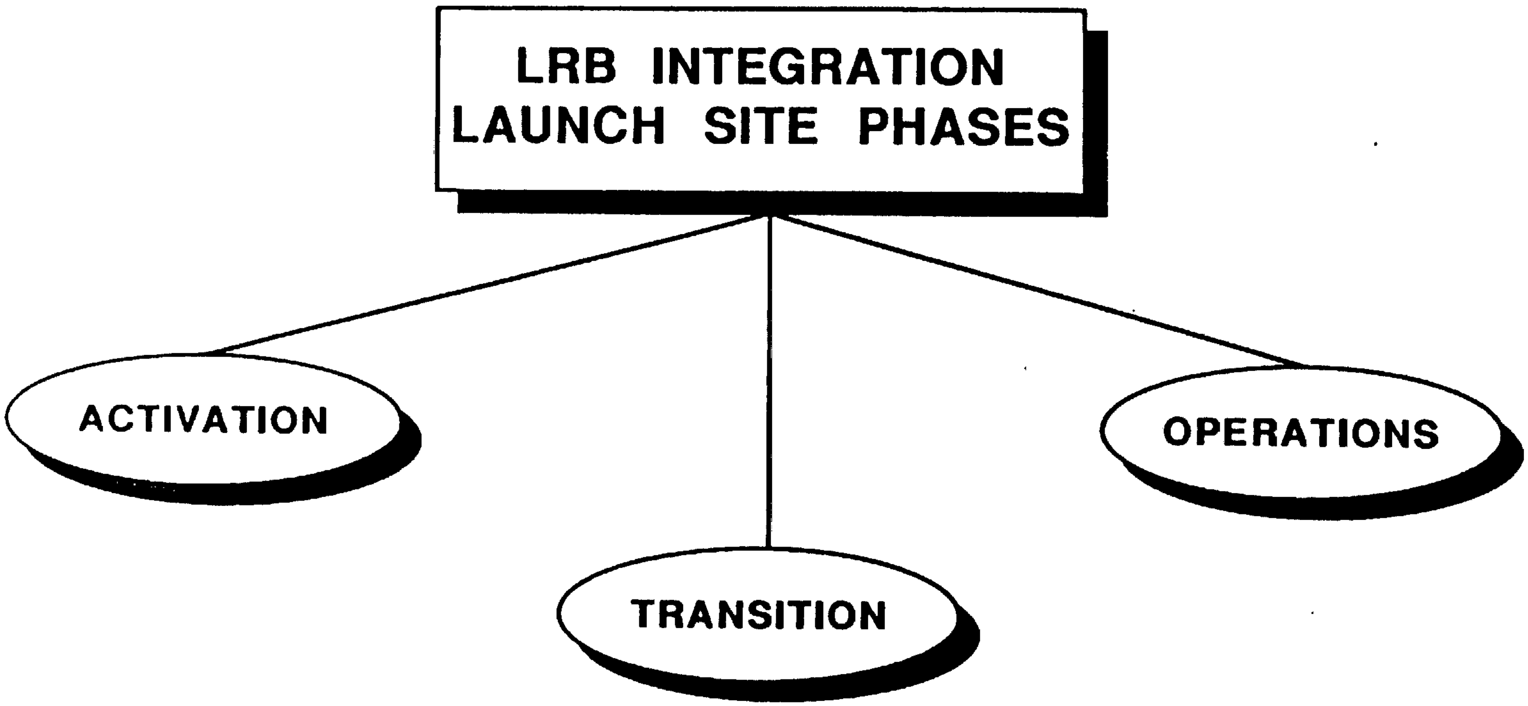
INTEGRATION PHASES



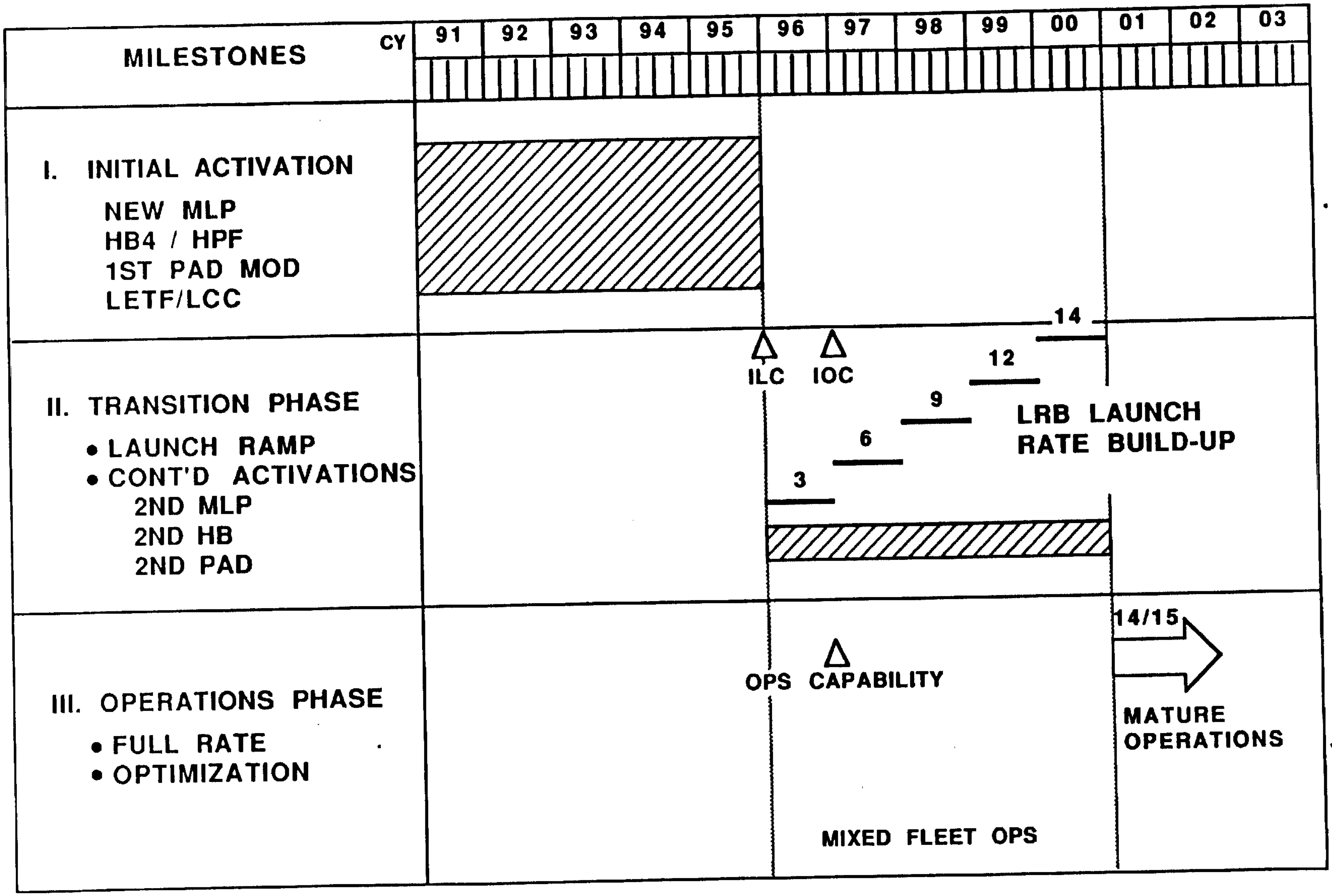
LRB INTEGRATION - A PHASED APPROACH

- LAUNCH SITE ACTIVATION BEGINS IN FY 91 TO SUPPORT INITIAL LRB LAUNCH CAPABILITY IN 1996. FIRST LINE NEW FACILITIES, REQUIRED FACILITY MODS AND NEW GSE/LSE ARE DESIGNED, CONSTRUCTED AND VALIDATED DURING THIS INITIAL FIVE YEAR PERIOD. THESE ACTIVATION SCHEDULES ARE LAID OUT IN AN ARTEMIS MODEL AND PLANNED ON A NON-INTERFERENCE BASIS.

- THE TRANSITION PHASE BEGINS WITH 3 LAUNCHES OF LRB IN 1996 AND BUILDS TO THE FULL 14 ANNUAL LAUNCH MANIFEST BY THE YEAR 2000. DURING THIS PERIOD SRB-BOOSTED LAUNCHES ARE PHASED DOWN BY SIMILAR INCREMENTS. AS YOU CAN SEE, ADDITIONAL FACILITY (AND GSE) ACTIVATIONS ARE SCHEDULED OVER THIS TPANSITION - MAJOR ONES ARE NOTED HERE.

- TOTAL LIFE CYCLE EVALUATIONS ARE DIMENSIONED OVER AN APPROXIMATE 10-YEAR LAUNCH PERIOD. THE LAST 5 YEAPS ARE AT THE FULL 14/15 FLIGHTS PER YEAR RATE. A TOTAL LRB LIFE OF 122 MISSIONS IS CURRENTLY PROJECTED.

PHASED APPROACH



LAUNCH SITE PLANNING

- THE DEVELOPED STUDY PRODUCTS SUPPORT THE PHASED PLANNING OF LRB LAUNCH SITE INTEGRATION.
- ACTIVATION ACTIVITIES IN THE FIRST PHASE ARE SUPPORTED BY THESE IDENTIFIED STUDY PRODUCTS DEALING WITH FACILITY DESIGN/CONSTRUCTION.
- TRANSITION ISSUES ARE DESCRIBED IN THE KEY PRODUCTS OF THE SECOND PHASE
- OPERATIONAL ISSUES DOMINATE THESE STUDY PRODUCTS OF THE THIRD PHASE
- THE GROUND OPERATIONS COST MODEL (GOCM) SUMMARIZES COST ELEMENTS PARAMETRICALLY OVER ALL THREE PHASES OF LAUNCH SITE IMPLEMENTATION.

LRB LAUNCH SITE PLANNING

ACTIVATION	TRANSITION	OPERATIONS
• GROUND OPERATIONS PLAN	• PRELIMINARY TRANSITION PLAN	• LRB PROCESSING TIMELINES
• FACILITY CONCEPTS (GSE / LSE)	• MANPOWER / COSTS	• OPERATIONAL EFFICIENCIES
• PROPELLANT STORAGE AND HANDLING	• IMPACTS TO ON-GOING ACTIVITIES	• LRB ENGINE PROCESSING
• ENVIRONMENTAL / SAFETY IMPLICATIONS		

GROUND OPERATIONS COST MODEL

VLS/LRB PROCESSING SCENARIO

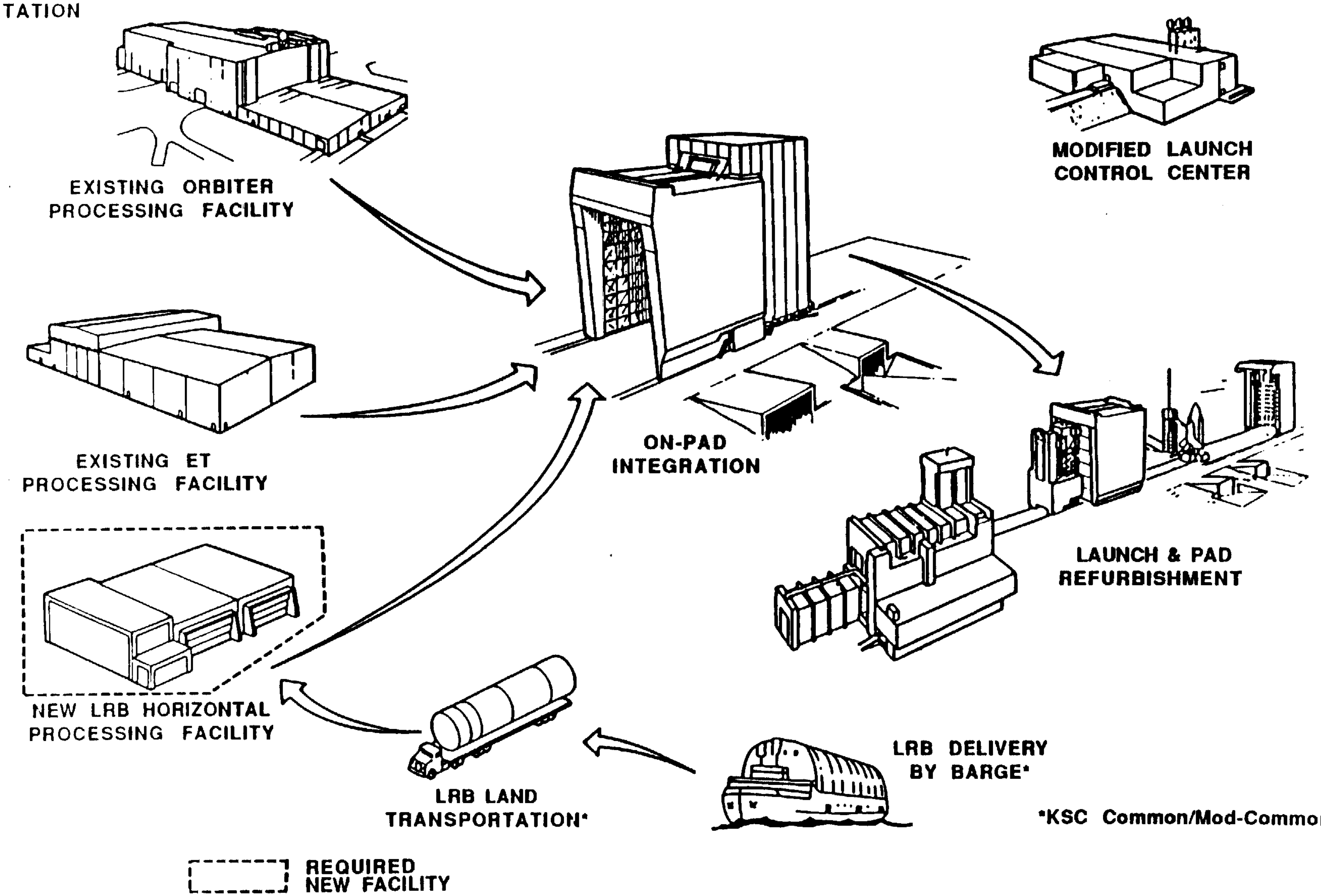
DELIVERY BY BARGE OF A COMPLETELY ASSEMBLED LRB TO THE EXISTING VLS DOCKING FACILITY SIMPLIFIED THE VLS FLOW PROCESSING FROM THE CURRENT RAIL DELIVERY OF SRB PROPELLANT SEGMENTS AND AIR DELIVERY OF ITS OTHER COMPONENTS. LAND TRANSPORTATION FROM THE DOCKING FACILITY WILL BE BY TRANSPORTER TOW, IDENTICAL TO THE KSC CONCEPT. ALL LRB STAND-ALONE CHECKOUT AND TESTING WILL BE CONDUCTED IN THIS FACILITY. EACH LRB WILL THEN BE TOWED ON ITS TRANSPORTER TO THE SLC-6 LAUNCH PAD WHERE IT WILL BE ERECTED BY THE EXISTING MST AND SAB CRANES. THE MST CRANE WILL THEN LIFT AND TRANSLATE EACH LRB IN A VERTICAL ATTITUDE TO ITS RESPECTIVE HOLDDOWN POSTS. THE BALANCE OF THE VLS SHUTTLE VEHICLE INTEGRATION WILL REMAIN UNCHANGED.

INCORPORATION OF EXTENSIVE LAUNCH MOUNT MODIFICATIONS OR REPLACEMENT BY A NEW LAUNCH FIXTURE WILL PROVIDE THE NECESSARY HOLDDOWN MODIFICATIONS AND ENLARGED BOOSTER DUCT ENTRANCE AREA. THIS ARRANGEMENT WILL PROVIDE CONTROL AND GUIDANCE OF THE EXHAUST PLUME INTO THE EXISTING VLS CLOSED DUCTS. THERE MAY BE A REQUIREMENT FOR STEAM INERTING THE BOOSTER CLOSEOUT DUCTS TO PRECLUDE A POTENTIALLY HAZARDOUS OVERPRESSURE.

VEHICLE LAUNCH PROCESSING WILL BE MODIFIED TO PROVIDE FOR EXPANDED LOX AND LH_2 CAPACITY AND LOADING (OR INSTEAD OF LH_2 THE ADDITION OF RP-1 FUEL CAPABILITY, IF IT IS SELECTED).

ADDITIONALLY, THE LAUNCH CONTROL CENTER WILL INCORPORATE THE NEW LRB CONSOLES AND GROUND SOFTWARE, SIMILAR TO KSC.

VLS LRB PROCESSING SCENARIO



*KSC Common/Mod-Common

- THE SHARED FACILITIES AND MANPOWER DURING TRANSITION CONSTITUTE SIGNIFICANT RISK OF LAUNCH DELAYS, EVEN THOUGH THE PLANNED LRB PROCESSING SCENARIO IS DESIGNED TO MINIMIZE RISKS TO THE SCHEDULE OF ON-GOING LAUNCH ACTIVITIES. SCHEDULE RISK IS, IN GENERAL, INSENSITIVE TO THE SELECTED LRB DESIGN.

- INTEGRATION OF LRB AT KSC WILL REQUIRE NEW AND MODIFIED FACILITIES AND GSE.

  NEW - MLPs (2)
  - HORIZONTAL PROCESSING FACILITY FOR LRB AND ET OFFLINE PROCESSING

  MODS - PADS (2)
  - VAB (HB-4 AND HB-3)
  - LCC (AND LPS)
  - LETF (MODS AND TESTING)

- PAD MODIFICATION TIMELINES DO NOT FIT THE AVAILABLE OPEN WINDOWS (AT 14 LAUNCHES PER YEAR) FOR THE THE CONSTRUCTION TO IMPLEMENT LRB CHANGES. DURING LRB PAD MODIFICATION APPROXIMATELY EIGHT MONTHS OF EXCLUSIVE ACCESS MAY BE REQUIRED. DURING THIS PERIOD ALL LAUNCHES ARE FORCED TO THE OTHER PAD. THESE SINGLE PAD LAUNCH OPERATIONS MUST BE COMPRESSED TO ACHIEVE THE PLANNED LAUNCH RATES.

- NEW MLP DESIGN AND CONSTRUCTION IS THE CRITICAL PATH ACTIVITY TO MEET FIRST LRB LAUNCH IN FY96. (ASSUMES A FY91 ATP).

- KEY LRB CONFIGURATION DESIGN FEATURES WERE IDENTIFIED WHICH RESULT IN ENHANCED LAUNCH SITE OPERATIONS.

- LOX/RP-1 AND LOX/LH2 ARE BOTH VIABLE AND ACCEPTABLE PROPELLANTS FOR THE NEW LRB AT KSC. OTHER PROPELLANTS STUDIED WERE LESS ACCEPTABLE. LOX/LH2 IS THE PREFERRED PROPELLANT AT THE LAUNCH SITE.

OBJECTIVES/FINDINGS

STUDY OBJECTIVES	LRBI KEY STUDY FINDINGS/ACCOMPLISHMENTS
1. IMPACTS (OPS + FAC)	• SHARED FACILITIES/MANPOWER ARE SIGNIFICANT TRANSITION RISK • NEW LRB FACILITIES REQUIRED PLUS MODS TO EXISTING • MOST SCHEDULE-CRITICAL FAC. MODS ARE PADS A&B • MOST SCHEDULE-CRITICAL NEW FAC. IS TWO MLPs
2. SCENARIOS	• LRB PROC. SCENARIO DESIGNED TO AVOID SCHED. RISK • DETAILED LRB PROCESSING TASKS DEFINED
3. LRB DESIGN RECOM	• LRB DESIGN FEATURES ID'ED FOR L.S. OPS EFFICIENCY • LOX/LH2 IS KSC PREFERRED PROPELLANT • L.S. CONSTRAINTS ID'ED TO ACCOMMODATE LRB OPTIONS

- LRB HAS A SIGNIFICANTLY SHORTER INTEGRATION TIMELINE ON THE MLP, IN THE VAB, COMPARED TO SRB. THIS FEATURE PROVIDES GREATER LAUNCH SITE CAPABILITY TO ACHIEVE A 14 PER YEAR LAUNCH RATE.

- THE GROUND OPERATIONS COST MODEL (GOCM) HAS BEEN SHOWN TO BE A USEFUL PARAMETRIC TOOL FOR PHASE-A COST ANALYSIS. THE MODEL HAS BEEN ENHANCED, APPLIED TO THE LRB LAUNCH SITE INTEGRATION AND DOCUMENTED. IN ITS CURRENT FORM IT IS READY TO APPLY TO ANY EMERGING NEW LAUNCH VEHICLE EVALUATION AT KSC.

- LAUNCH SITE COSTS ARE APPROXIMATELY $1B NON-RECURRING AND $1B RECURRING FOR A 10-YEAR (122 MISSION) LIFE CYCLE. COST SAVINGS DUE TO SRB PHASE-OUT STILL REQUIRE FURTHER EVALUATION.

- EXTENT OF MODIFICATIONS TO EXISTING FACILITIES AND COSTS IS HIGHLY SENSITIVE TO SELECTED LRB DESIGN CHARACTERISTICS (PROPELLANT, LENGTH, DIAMETER, ETC.).

- MANPOWER REQUIREMENTS WILL PEAK DURING FY94-FY95 AT AN ADDITIONAL 800 PEOPLE TO SUPPORT ACTIVATION, TRANSITION AND OPERATIONAL PHASES OF LRB IMPLEMENTATION PLUS APPROXIMATELY 1500 A&E AND CONSTRUCTION INSTALLATION CONTRACTOR PERSONNEL.

- KSC NEEDS A DEDICATED ACTIVATION TEAM FOR LRB ACTIVATION AND TRANSITION PLANNING WITH FOLLOW-THRU TO IMPLEMENT NEW BOOSTER OPERATIONS.

OBJECTIVES/FINDINGS

STUDY OBJECTIVES	LRBI KEY STUDY FINDINGS/ACCOMPLISHMENTS
4. OPER. EFF. LRB	• KEY LRB DES FEATURES ID'ED FOR L.S. OPS EFFICIENCY • L.S. PROCESSING ADVANTAGES OF LRB DEFINED
5. COST MODEL	• GOCM IMPROVED AND DOCUMENTED • LRB LAUNCH SITE PROJECTED COSTS DEFINED
6. LSE - GSE	• CONCEPT LEVEL GSE - LSE DEFINED TO ACCOM. LRB
7. LAUNCH SITE SUPPORT PLAN	• MANPOWER FOR ACTIVATION, TRANSITION, OPS DEFINED • KSC NEEDS DEDICATED ACTIVATION TEAM FOR LRB INTEG.

LIQUID ROCKET BOOSTER INTEGRATION

AGENDA

I. INTRODUCTION	Gordon Artley
II. LRBI RESULTS	
BASELINE / LAUNCH SITE SCENARIO	Pat Scott
FACILITIES AND GROUND SYSTEMS	Greg DeBlasio
IMPLEMENTATION	Gordon Artley
COST	Jerry Lefebvre
III. SUMMARY	Gordon Artley

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STATION SET APPROACH

- FACILITY REQUIREMENTS AND IMPACTS
- IDENTIFY NEW FACILITIES
- DEFINE LRB LAUNCH SUPPORT EQUIPMENT
- DEFINE LRB GROUND SUPPORT EQUIPMENT
- DEFINE LRB PROPELLANT REQUIREMENTS

EVALUATION OF LRB PROCESSING/STORAGE IN THE VAB

THIS STUDY ADDRESSED FACILITY REQUIREMENTS FOR RECEIVING, PROCESSING, AND STORING LRB's IN THE VEHICLE ASSEMBLY BUILDING (VAB). THE LRB PROCESSING FLOW WAS ANALYZED AND ACTIVATION, OPERATIONAL, AND SAFETY IMPACTS WERE IDENTIFIED INCLUDING CRANE LIFT OPERATIONS AND HAZARDOUS CLEAR AREAS. OPERATIONAL COMPARISONS WERE MADE TO EVALUATE USE OF AN EXTERNAL ET AND LRB FACILITY.

CONCEPT 1

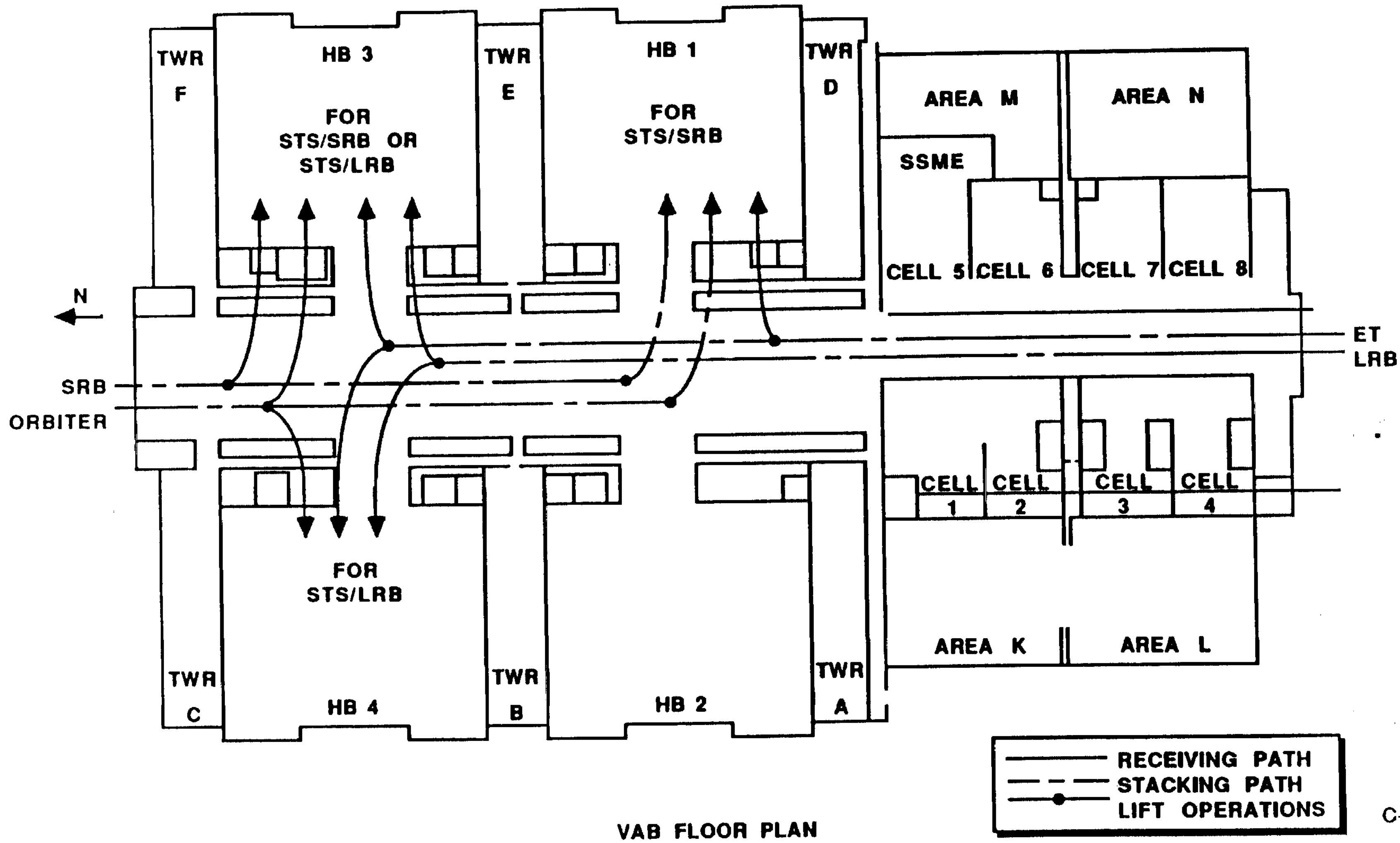
THE CONCEPTUAL FLIGHT HARDWARE FLOW PATH USES VAB HIGH BAYS 1 AND 3 AS INTEGRATION CELLS AND VAB HIGH BAYS 2 AND 4 AS LRB/ET PROCESSING AND STORAGE AREAS. THE ET PROCESSING WOULD NOT BE CHANGED. PHASE 1 ACTIVATION WOULD BE IN HIGH BAYS 3 AND 4 TO SUPPORT FIRST LRB FLOW.

CONCEPT 2

THIS CONCEPTUAL FLIGHT HARDWARE FLOW PATH USES VAB HIGH BAY 1 AS AN INTEGRATION CELL FOR SRB/SSV, VAB HIGH BAY 3 AS AN INTEGRATION CELL FOR SRB/SSV OR LRB/SSV, AND HIGH BAY 4 AS AN INTEGRATION CELL FOR LRB/SSV. HIGH BAY 2 WOULD BE USED FOR THE SRB BUILDUP WORKSTAND TO BACKUP THE RPSF. BOTH LRB AND ET PROCESSING AND STOPAGE REQUIREMENTS WOULD BE PERFORMED IN A HORIZONTAL FACILITY. THE FIGURE SHOWS THE FLOW PATH OF ALL THE ELEMENTS.

VAB RECOMMENDED CONCEPT

VAB HIGH BAY 1, 3 AND 4 AS INTEGRATION CELLS
ET PROCESSING AT HORIZONTAL FACILITY



VAB FLOOR PLAN

Lockheed Space Operations Company

LIFTING OPERATIONS IMPACTS/EVALUATION

THE CONCEPTS WERE EVALUATED TO ESTABLISH VAB CRANE UTILIZATION AND LIFT REQUIREMENTS.

THE CURRENT NUMBER OF LIFTS REQUIRED TO STACK A SRB/STS IS 14. THE TABLE SHOWS THAT 10 LIFTS ARE REQUIRED TO STACK/MATE THE BOOSTERS. THE PRESENT REQUIREMENT FOR ET's IS THREE (1 OFFLOAD, 1 FROM C-0 TO STORAGE CELL AND 1 TO MATE STACK).

CONCEPT 1 FOR LRB/STS WOULD REQUIRE SIX LIFT OPERATIONS TO STACK/MATE THE BOOSTERS IN HIGH BAY 1 OR 3. THE ET LIFTING REQUIREMENT REMAINS UNCHANGED AT THREE, FOR A TOTAL OF 10 LIFTS FOR STS.

CONCEPT 2 REQUIRES FOUR LIFT OPERATIONS TO STACK/MATE AN LRB/SSV IN HIGH BAY 3 OR 4. THE SRB/SSV STACKING/MATING OPERATIONS WOULD REQUIRE ONLY ONE LIFT OF AN ET USING THIS CONCEPT. THIS IS A TOTAL REDUCTION OF TEN LIFTS FROM THE CURRENT SRB/SSV INTEGRATION REQUIREMENTS.

SINCE LIFTING FLIGHT HARDWARE IS A HAZARDOUS OPERATION REQUIRING AREA CLEARS, MINIMIZING THE NUMBER OF LIFTS REPRESENTS A SIGNIFICANT SAFETY ENHANCEMENT FOR THE ENTIRE STS LAUNCH PROCESSING. AT A RATE OF 14 PER YEAR THERE WILL BE 140 LESS OPPORTUNITIES PER YEAR FOR MAJOR LIFTING INCIDENTS. THIS IS A 70% REDUCTION IN TOTAL REQUIRED LIFTS (AND THE LRB HAS TO LIVE PROPELLANTS ON-BOARD).

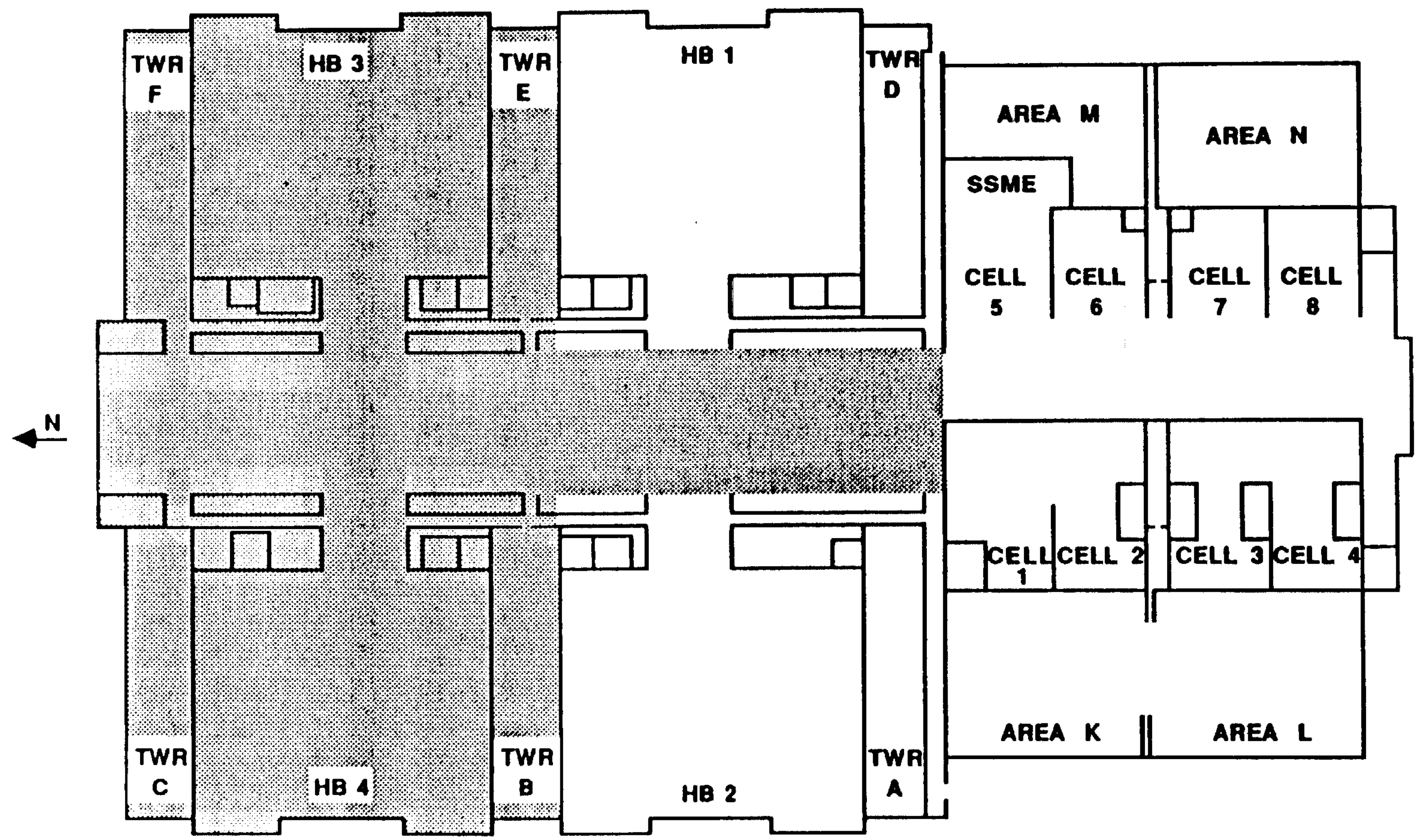
VAB LIFT OPERATIONS SUMMARY

	LIFTS PER FLIGHT SET			TOTAL
	BOOSTER	ET	ORB	
CURRENT SRB/STS	10	3	1	14
CONCEPT 1 LRB/STS (ET/LRB PROCESSED IN VAB)	6	3	1	10
CONCEPT 2 LRB/STS (ET/LRB PROCESSED IN HFP)	2	1	1	4

SRB PROCESSING IN THE VAB

CURRENTLY, THE SRB's ARE BUILT UP AND PROCESSED IN THE RPSF. THEY ARE THEN TRANSPORTED TO THE VAB, LIFTED, AND STACKED ON THE MOBILE LAUNCHER PLATFORM (MLP). DURING THE VAB SRB STACKING OPERATIONS, AREAS OF THE TRANSFER AISLE AND HIGH BAYS 2 AND 4 ARE CLEARED. THE FIGURES SHOW THE CLEAR AREAS FOR HIGH BAY 1 OR 3 STACKING. THIS REQUIREMENT TO CLEAR FOR SRB STACKING COULD IMPACT THE LRB PROCESSING SCHEDULE AS WELL AS THE ACTIVATION OF ANY HIGH BAY FOR LRB PROCESSING OR INTEGRATION.

SRB STACKING CLEAR ZONE - HIGH BAY 3



VAB FLOOR PLAN

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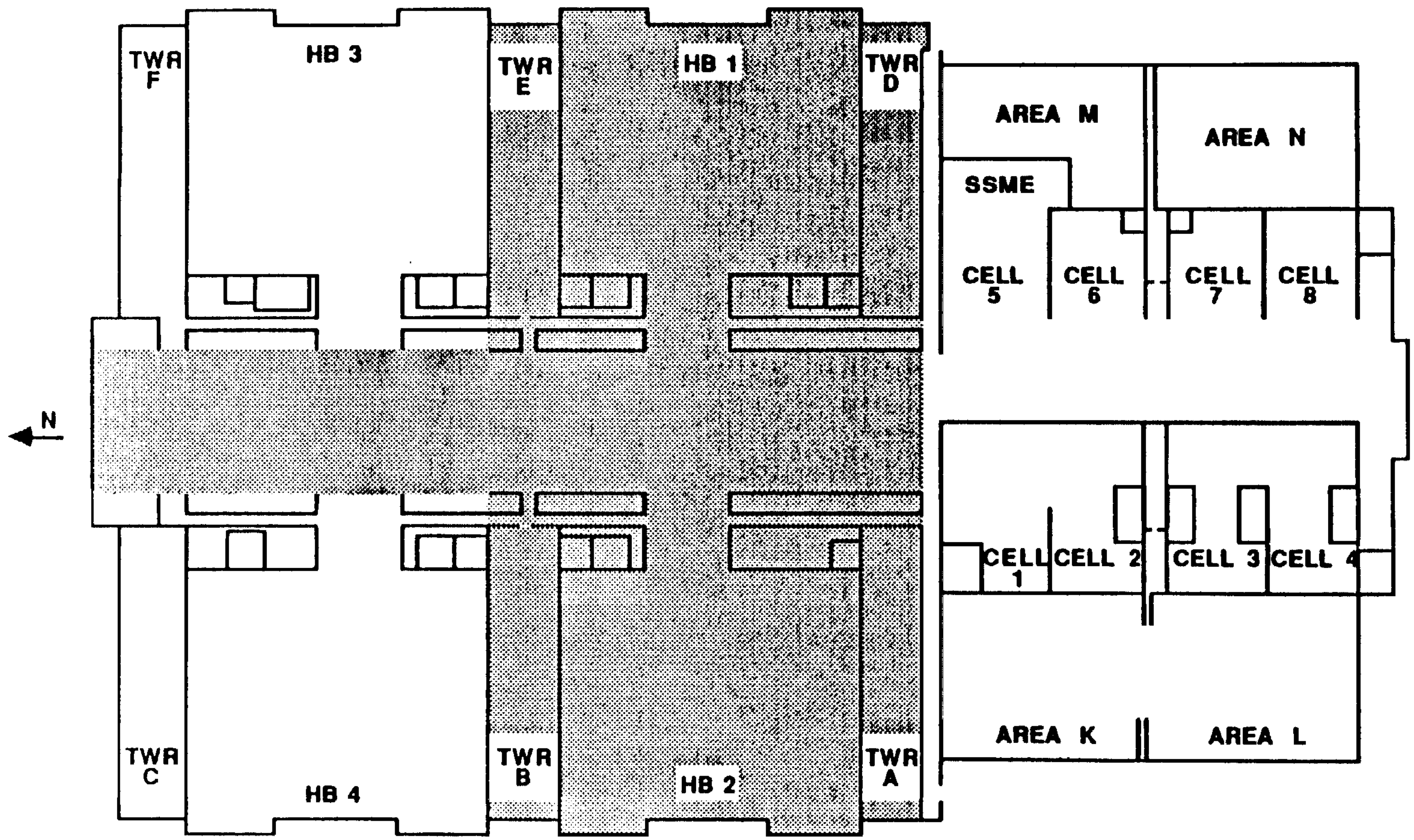
SRB STACKING CLEAR ZONE - VAB HIGH BAY 1



VAB FLOOR PLAN

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VAB PROCESSING AND STORAGE CONCLUSIONS

- PROCESSING IN VAB COMPLICATED BY NUMEROUS LIFTS / AREA CONTROLS / SCHEDULE INTERACTION

- ACTIVATION IN VAB WILL IMPACT ON-GOING OPERATIONS

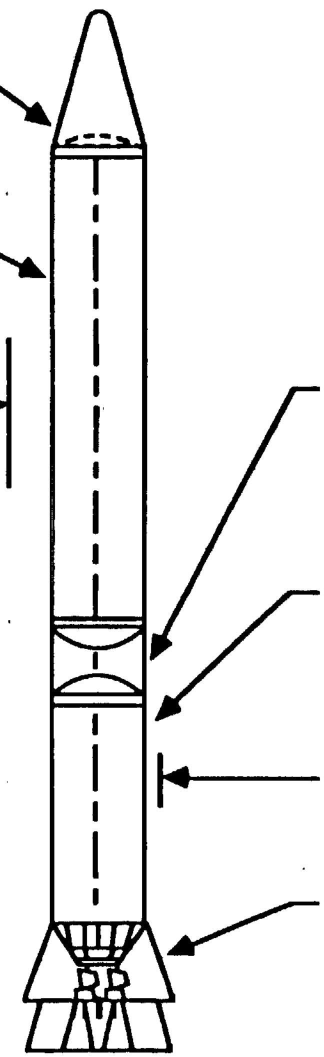
- FUTURE USE OF VAB LIMITED

LRB HORIZONTAL PROCESSING REQUIREMENTS

THE METHODOLOGY OF THIS STUDY ESTABLISHED A COMPARISON BETWEEN THE LRB PUMP-FED PROPELLANT SYSTEM AND THE ORBITER/ET PUMP-FED PROPELLANT SYSTEM PROCESSING OPERATIONS SINCE THE ET AND ORBITER ENGINES CONTAIN SIMILAR PHYSICAL CHARACTERISTICS; e.g., THIN WALL CONSTRUCTED LIQUID PROPELLANT STORAGE TANKS, MAIN ENGINES, INTERTANK ACCESS, A NOSE CONE, A GROUND SUPPORT EQUIPMENT (GSE) INTERFACE, A TANK/ENGINE INTERFACE, AND AN EXTERIOR NETWORK OF SHUTTLE RANGE SAFETY SYSTEM (SRSS) ORDNANCE AND THERMAL PROTECTION SYSTEM (TPS).

THE STUDY TEAM DEFINED THE CONCEPTUAL FUNCTIONAL PROCESSING AND TEST REQUIREMENTS FOR LRB BY ANALYZING THE PRESENT DAY STORAGE AND CHECKOUT PROCEDURES FOR THE ET AND ORBITER MAIN ENGINES. THE FUNCTIONAL REQUIREMENTS FOR LRB STORAGE AND CHECKOUT PROCESSING WERE THEN DEVELOPED.

PROCESSING FUNCTIONAL REQUIREMENTS



NOSE CONE REQUIREMENTS
ASCENT AIR DATA SYSTEM (AADS) ALIGNMENT
FAIRINGS REMOVAL/INSTALLATION/INSPECTION
NON-RETRIEVAL SYSTEM CHECKOUT

OXIDIZER TANK REQUIREMENTS
PRESSURE MAINTENANCE/MONITORING
PURGE/PRESSURIZATION SAMPLING
LEAK AND FLOW CHECKS
VENT/ RELIEF VALVES FUNCTIONAL CHECKOUT

EXTERIOR REQUIREMENTS
THERMAL PROTECTION SYSTEM (TPS) CLOSE OUT
FLIGHT ACCESSORIES INSTALLATION/INSPECTION
SUPPORT FIXTURE VERIFICATION
FAIRINGS INSTALLATION/INSPECTION
SRSS-SHUTTLE RANGE SAFETY SYSTEM

INTERTANK ACCESS REQUIREMENTS
LEAK AND FLOW CHECKS
ELECTRICAL/INSTRUMENTATION INSTALLATION
HAZARDOUS PURGE SYSTEM VALIDATION
SRSS-SHUTTLE RANGE SAFETY SYSTEM INSTALLATION

FUEL TANK REQUIREMENTS
PURGE/PRESSURIZATION/SAMPLING
PRESSURE MAINTENANCE/MONITORING
LEAK AND FLOW CHECKS
VENT/RELIEF VALVES FUNCTIONAL CHECKOUT

GSE INTERFACE FUNCTIONAL REQUIREMENTS
LEAK CHECKS
DISCONNECT FUNCTIONAL CHECKS

ENGINE REQUIREMENTS
PURGE/PRESSURIZATION/SAMPLING
HEATED PURGE
LEAK CHECKS
FUNCTIONAL CHECKOUT
REMOVAL/INSTALLATION

FLUID GSE FOR LRB PROCESSING

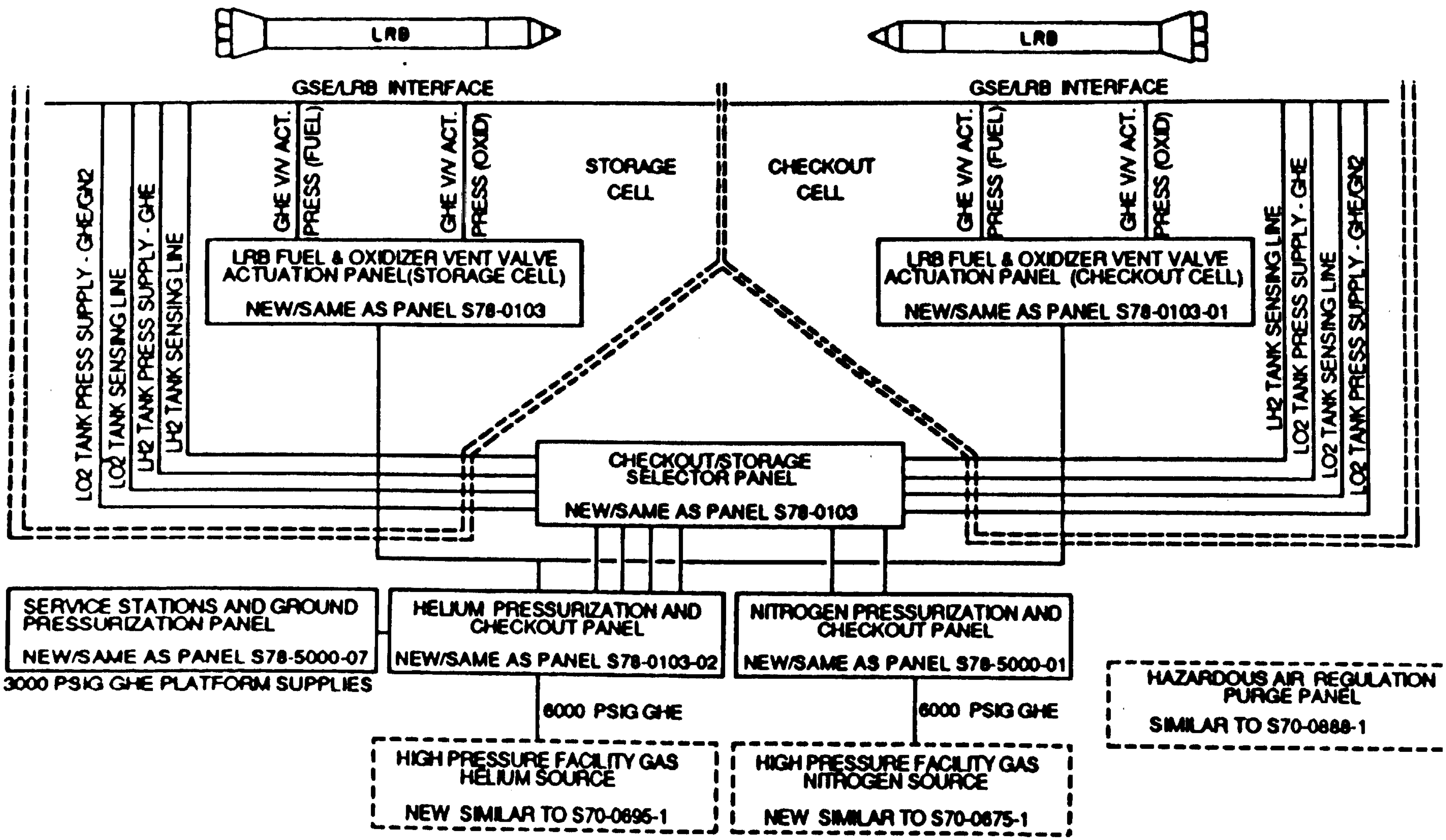
A SOURCE FOR HIGH PRESSURE GASES AND COMPRESSED AIR TO SUPPLY THE ET/LRB HORIZONTAL PROCESSING FACILITY WILL BE REQUIRED. FABRICATION OF GSE WILL BE BASED ON EXISTING FACILITY GSE DESIGN AT THE ORBITER PROCESSING FACILITY (OPF).

THE OPF PNEUMATIC SYSTEM UTILIZES THREE PERMANENTLY INSTALLED PANELS OUTSIDE THE BUILDING. THESE PANELS MONITOR, CONTROL, AND DISTRIBUTE GASEOUS GN_2 GHe, AND A HAZARDOUS AIR PURGE AT VARIOUS PRESSURES, TEMPERATURES, AND FLOW RATES TO THE HIGH BAYS. THE FACILITY GSE FOR THE NEW HPF WILL CONSIST OF SIMILAR EQUIPMENT.

THE FACILITY WILL HAVE ITS OWN SUPPLY OF HIGH PRESSURE GASES AND COMPRESSED AIR SYSTEM FOR HAZARDOUS PURGE AND SHOP TOOLS. A SEPARATE AREA TO HOUSE THE 6000-psig HIGH PRESSURE GAS STORAGE TANKS FOR GHe AND GH2 WOULD BE LOCATED AS NEAR TO THE CCF/VAB GHe PIPELINE AS POSSIBLE AND THE BIG THREE GN2 PIPELINE. THE GHe WILL BE SUPPLIED FROM THE CCF, WHILE THE GN_2 WILL BE SUPPLIED BY A BIG THREE PIPELINE. A UTILITY ANNEX WILL BE REQUIRED AT THE HPF TO HOUSE THE AIR COMPRESSOR AND OTHER UTILITIES.

THE GROUND SUPPORT SYSTEM FOR SERVICING THE LRB TANKS CONSISTS OF A NETWORK OF PNEUMATIC PANELS TO REGULATE AND DISTRIBUTE FACILITY HELIUM AND NITROGEN GASES FOR PRESSURIZATION, MONITORING, AND MAINTENANCE OF TANK PRESSURES, VENT VALVES FUNCTIONAL CHECKS, AND VARIOUS LEAK CHECKS ASSOCIATED WITH LRB PROCESSING.

HPF LRB PNEUMATIC GSE



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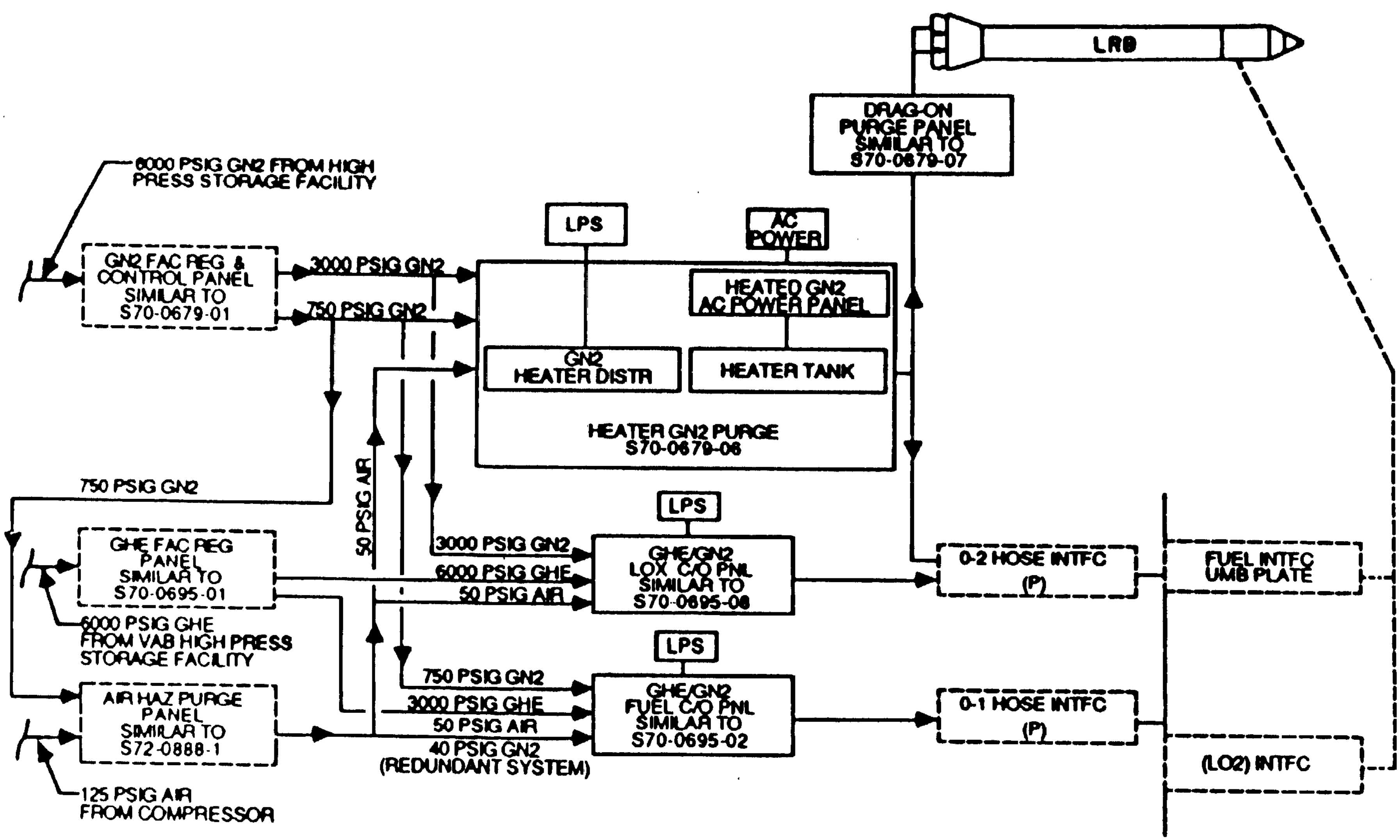
HPF LRB ENGINE SERVICING GSE



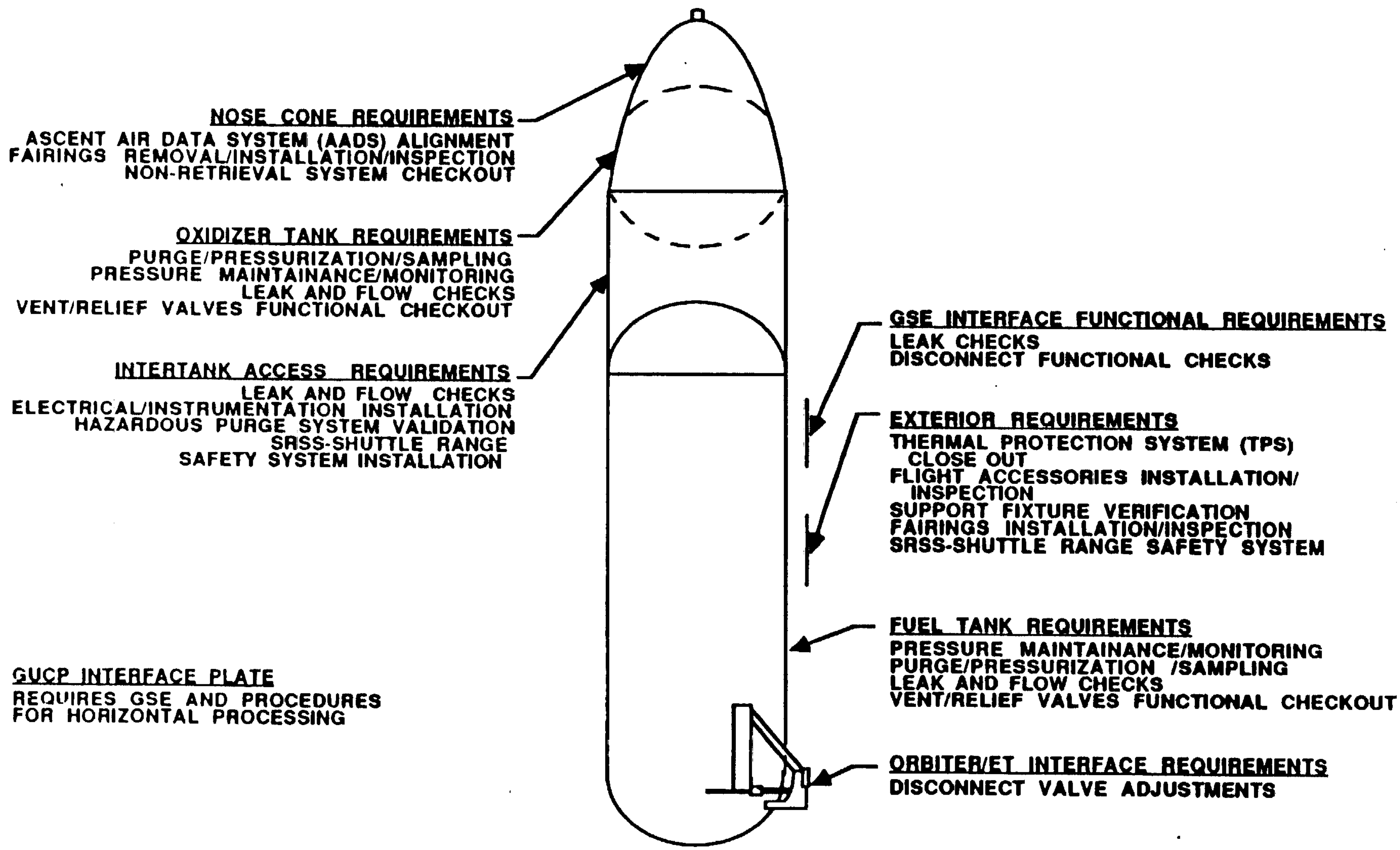
ET HORIZONTAL PROCESSING REQUIREMENTS

THE ET WILL BE PROCESSED WHILE INSTALLED ON AN ET TRANSPORTER IN THE NEW ET/LRB HORIZONTAL PROCESSING FACILITY.

CONCLUSIONS/RECOMMENDATIONS

THE ET TANK's PROCESSING OPERATIONS IN A HORIZONTAL CONFIGURATION WOULD REQUIRE GSE AND OPERATIONAL PROCEDURES SIMILAR TO THOSE CURRENTLY IN USE. THE INTERFACING OF THIS EQUIPMENT TO THE ET WOULD REQUIRE ACCESS STANDS, FIXED PLATFORMS, AND PORTABLE PLATFORMS. THE HORIZONTAL INSTALLATION AND CHECKOUT OF THE GUCP IS QUESTIONABLE DUE TO LACK OF WORKSPACE AND CLEARANCES WITH ET IS ON THE TRANSPORTER; MODIFICATION OF THE TRANSPORTER WOULD BE REQUIRED TO ENABLE THE GUCP TO BE INSTALLED IN THE HORIZONTAL POSITION. A NEW CHECKOUT GSE INTERFACE MIGHT BE REQUIRED TO SUPPORT TANK PROCESSING. THE VERIFICATION MEASUREMENTS PERFORMED ON THE ET/ORBITER, LOX, AND HYDROGEN FLAPPER VALVES SHOULD BE PERFORMED VERTICALLY AFTER STACKING ON THE MLP TO PROTECT THE INNER TANK FROM CONTAMINATION.

ET FUNCTIONAL REQUIREMENTS

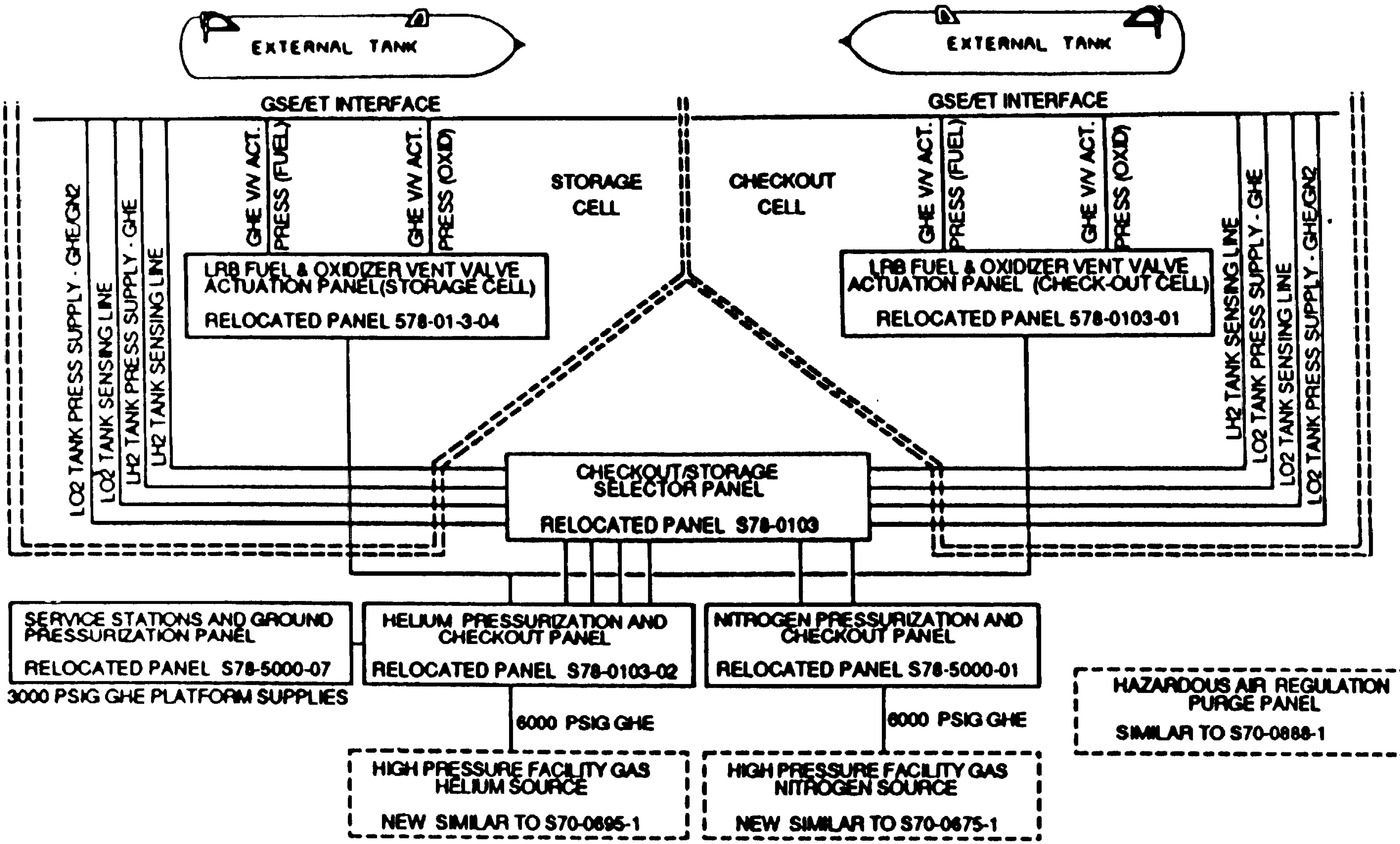


FLUID GSE FOR ET PROCESSING

THE GROUND SUPPORT SYSTEM FOR SERVICING THE EXTERNAL TANK (ET) WILL CONSIST OF A NETWORK OF PNEUMATIC PANELS TO REGULATE AND DISTRIBUTE FACILITY HELIUM AND NITROGEN GASES FOR PRESSURIZATION, MONITORING, AND MAINTENANCE OF TANK PRESSURES, VENT VALVES FUNCTIONAL CHECKS AND VARIOUS LEAK CHECKS ASSOCIATED WITH PROCESSING.

THE EXISTING ET PROCESSING GROUND SUPPORT SYSTEM PANELS IN THE VAB CAN BE RELOCATED TO THE NEW ET/LRB PROCESSING FACILITY.

HPF ET PNEUMATIC GSE



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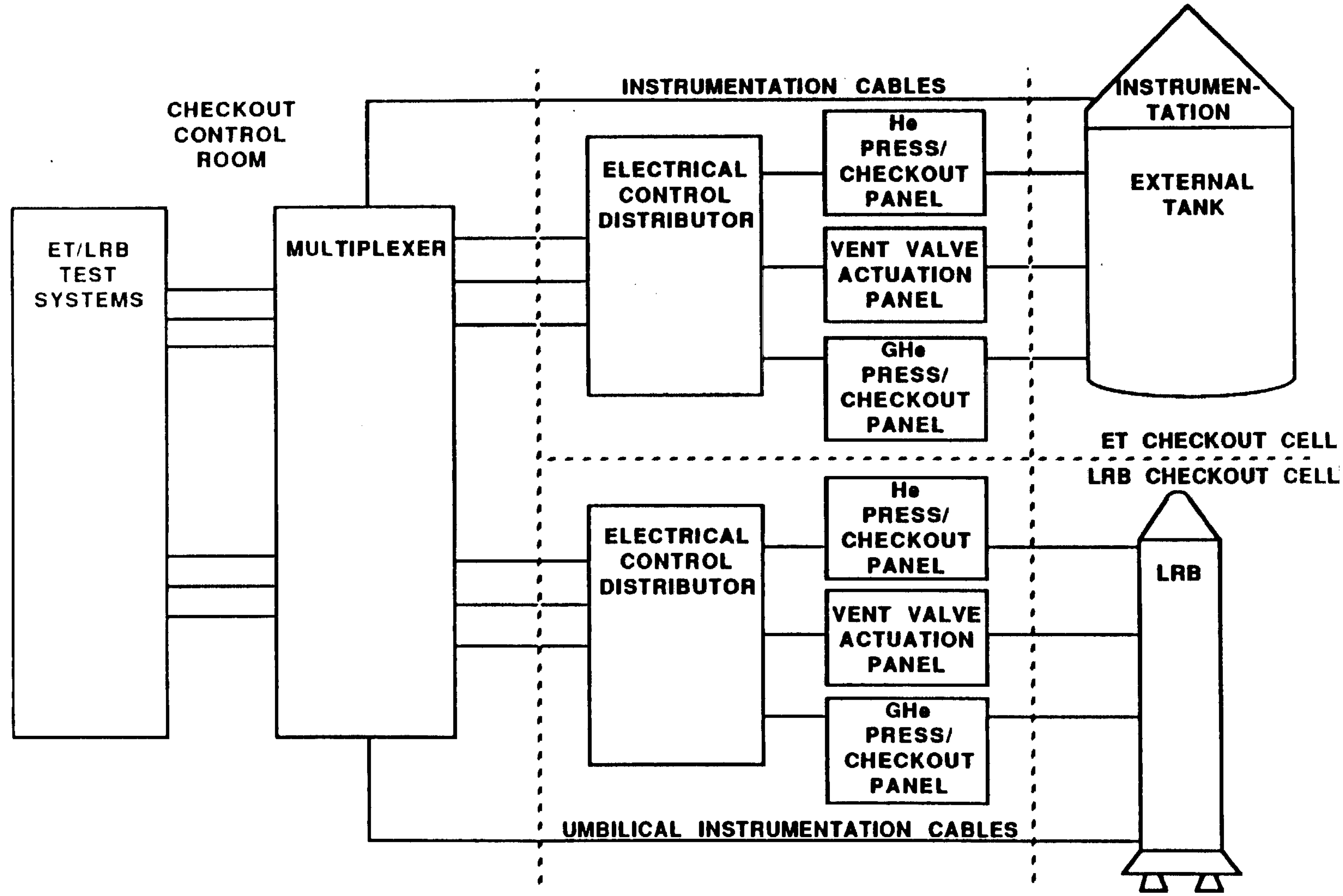
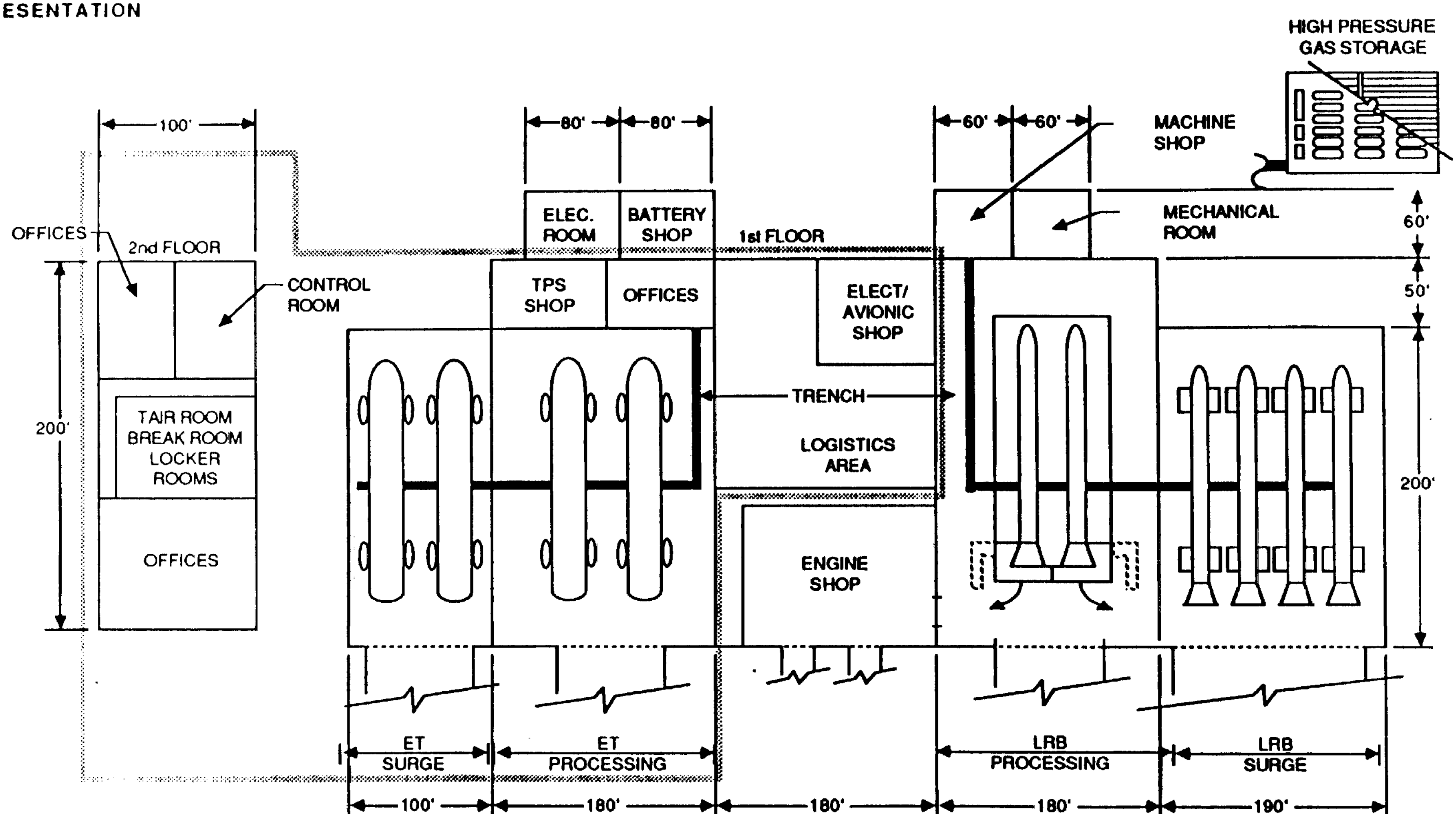
ET/LRB HPF ELECTRICAL CONTROLS



ET/LRB HORIZONTAL PROCESSING FACILITY CONCEPT

THE NEW OFFLINE FACILITY WILL PROVIDE THE CAPABILITY TO PROCESS TWO ET's AND FOUR LRB's HORIZONTALLY. SHOP AREAS ARE PROVIDED FOR ENGINE, BATTERY, TPS, AND ELECTRONICS/AVIONICS ACTIVITIES. THE PROCESSING BAY WILL PROVIDE CRANE SUPPORT AND SPACE FOR GSE; PLATFORMS AND STRUCTURES REQUIRED FOR ACCESS AND INSTALLATION; AND REMOVAL OF ENGINES, LRU's, AND OTHER COMPONENTS AND SUBSYSTEMS. FINAL CHECKOUT OF COMPONENTS AND SUBSYSTEMS OF THE LRB's AND ET's WILL BE CONDUCTED ON THE HPF. AREAS FOR LOGISTICS, GSE AND LRU STORAGE, OFFICE, AND CONTROL ROOM ARE PROVIDED. SPACE IS PROVIDED FOR FACILITY ELECTRICAL AND MECHANICAL EQUIPMENT, AND THERE WILL BE A HIGH PRESSURE GAS STORAGE AREA FOR HELIUM AND NITROGEN. FLOOR TRENCHES IN THE HIGH BAY AREAS ARE PROVIDED FOR CABLE AND GAS PIPING RUNS.

ET/LRP HPF LAYOUT



SQUARE FOOTAGE
238,000 MINIMUM
263,000 MAXIMUM

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HPF SITING

SELECTION TRADE STUDIES WERE CONDUCTED FOR FOUR POSSIBLE HPF SITES IN THE LC-39 AREA

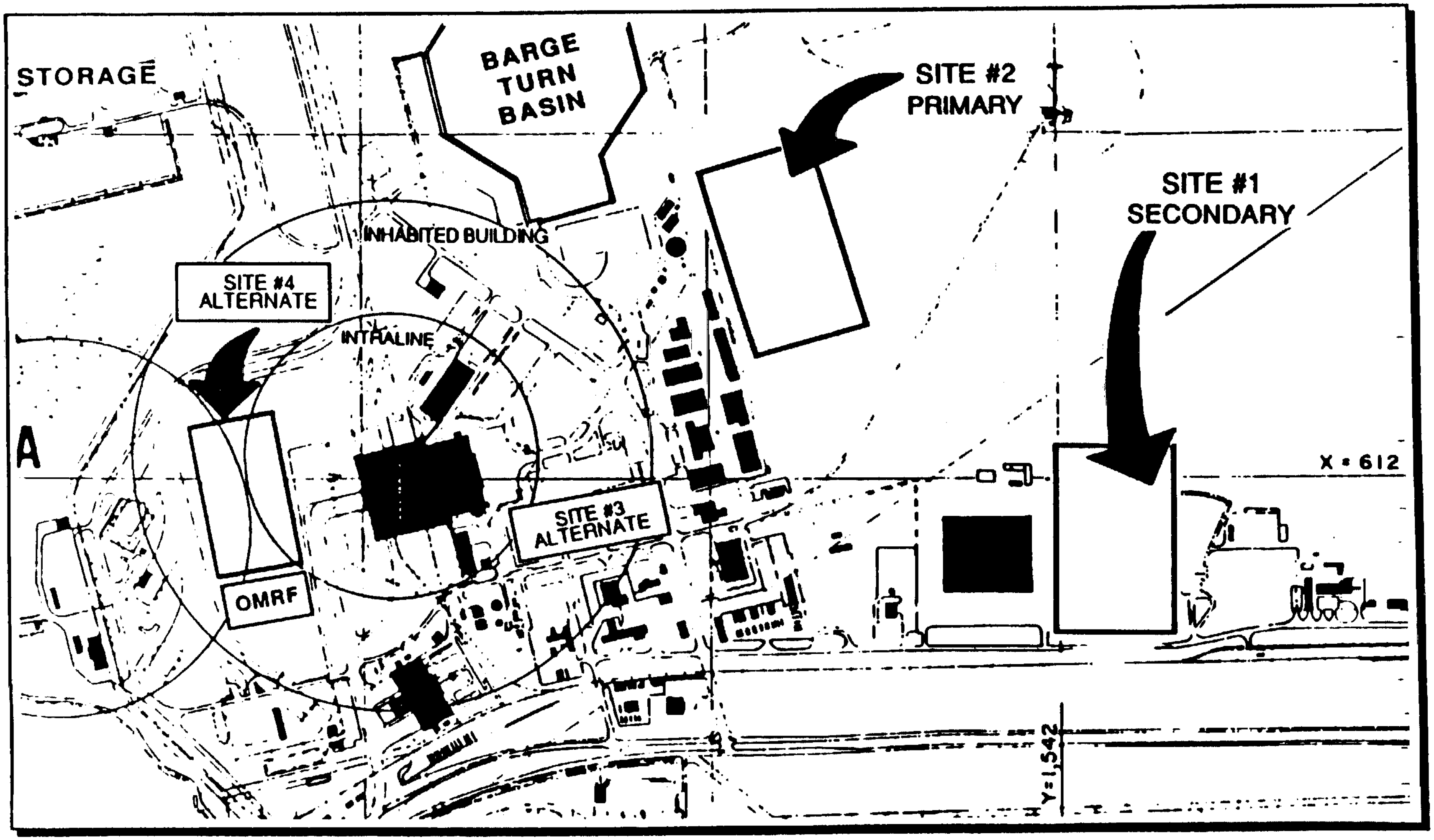
1. SOUTH OF THE SPC LOGISTICS FACILITY ON CONTRACTORS ROAD
2. SOUTH OF THE TURN BASIN ADJACENT TO THE PRESS SITE
3. SOUTHWEST OF THE VAB AND EAST OF THE MFF, (CURRENTLY A PARKING LOT)
4. NORTH OF THE VAB AND EAST OF THE ORBITER, MAINTENANCE, AND PROCESSING FACILITY (OMRF)

THE SITE NEAR THE PRESS SITE LOCATION IS RECOMMENDED, SINCE IT BEST SATISFIES THE MAJORITY OF THE SELECTION CRITERIA. THE LOCATION WOULD BE IN CLOSE PROXIMITY TO THE VAB, BARGE TERMINAL, EXISTING TOW ROUTE TO THE VAB, AND EXISTING FACILITIES AND SERVICES. THE SITE IS BEYOND THE VAB QUANTITY/DISTANCE AREA AND OUTSIDE THE CURRENTLY DEFINED LAUNCH DANGER AREA. LC-39 TRAFFIC CONGESTION WOULD NOT BE SIGNIFICANTLY INCREASED. TOW ROUTE CONSTRUCTION WOULD BE MINIMUM. SITE PREPARATION COSTS WOULD BE MINIMIZED BECAUSE THIS AREA IS CURRENTLY UTILIZED AND HAS ALREADY HAD ENVIRONMENTAL IMPACT STUDIES PERFORMED. A MINIMUM OF DEMOLITION AND RELOCATION OF FACILITIES IS REQUIRED.

PRIMARY TRADE SELECTION CRITERIA	SITE 1	SITE 2 (SELECTED)	SITE 3	SITE 4
SSV INTEGRATION FACILITY PROXIMITY	NG	GOOD	GOOD	GOOD
TURN BASIN PROXIMITY	NG	GOOD	NG	NG
BLAST DANGER AREA (QUANTITY/DISTANCE)	OUT	OUT	IN	IN
LAUNCH DANGER AREA	OUT	OUT	OUT	OUT
ENVIRONMENTAL IMPACTS	YES	NO	NO	NO
ET & LRB TOW ROUTES PROXIMITY	NG	GOOD	GOOD	NG
LC-39 AREA CONGESTION (INCLUDING TRAFFIC)	GOOD	GOOD	NG	NG
AVAILABILITY OF UTILITIES/SERVICES	NG	GOOD	GOOD	NG
DEMOLITION AND RELOCATION OF EXISTING FACILITIES	NO	YES	YES	NO
SITE PREPARATION COSTS	LOW	MED	MED	LOW

LEGEND
NG = NOT GOOD
MED = MEDIUM

ET/LRB HPF SITE PLAN



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ET/LRB HORIZONTAL PROCESSING FACILITY - CONTROL ROOM REQUIREMENTS

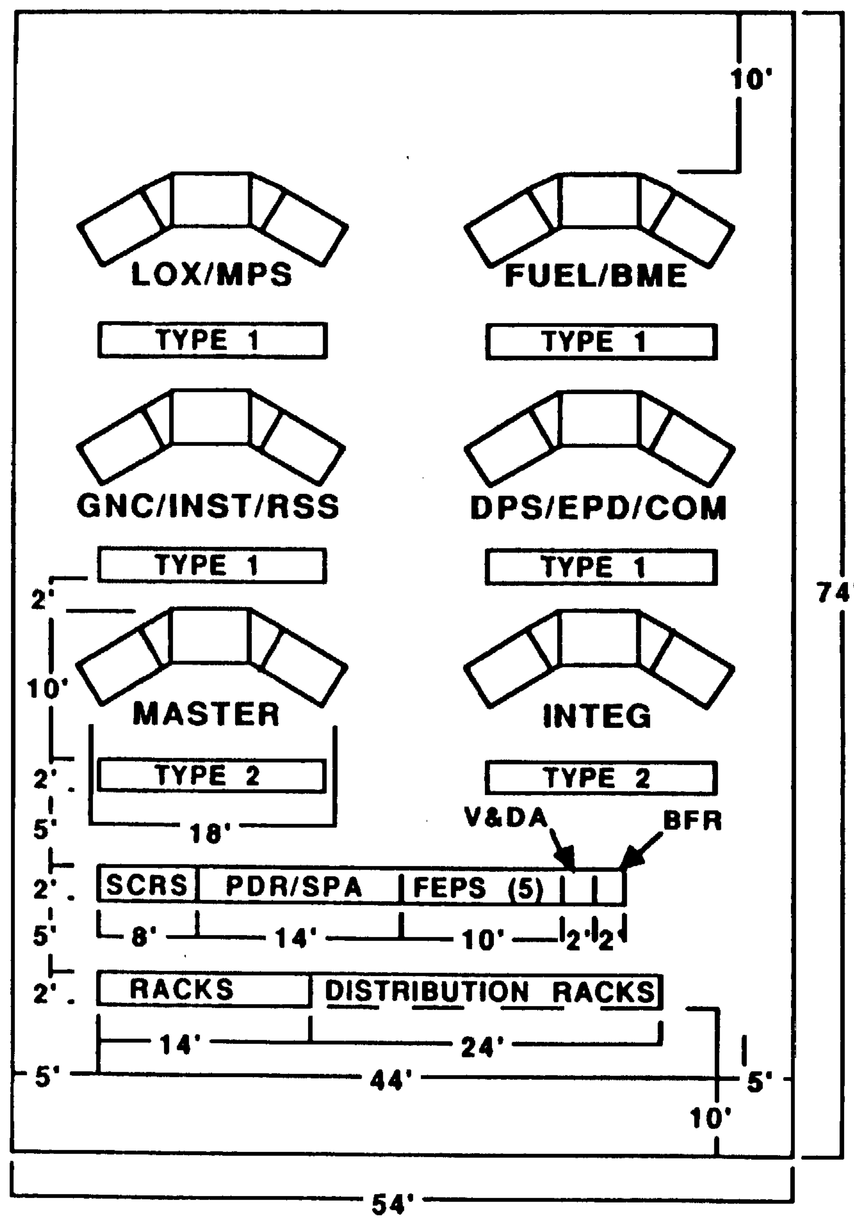
USE OF THE FIRING ROOMS IN THE LAUNCH CONTROL CENTER (LCC) TO PERFORM TESTING CAN BE RULED OUT. BASED ON THE ESTIMATES OF NEW LRB SYSTEMS THAT ARE EXPECTED TO UNDERGO TESTING PRIOR TO FLIGHT, THE INCREASE IN FIRING ROOM REQUIREMENTS WOULD BE GREATER THAN COULD BE PROVIDED BY THE EXISTING LCC EQUIPMENT WITHOUT IMPACTING ON-GOING SHUTTLE OPERATIONS.

AN INDEPENDENT CONTROL ROOM WILL BE PROVIDED IN THE HPF FOR THE PERFORMANCE OF ALL PRE-MATE CHECKOUT. THE NEW CONTROL ROOM WILL BE A MINI-FIRING ROOM FOR INITIAL TESTING OF LRB's AND ET's SOON AFTER THEIR ARRIVAL AND RETEST AFTER MAINTENANCE, REPAIR, OR MODIFICATIONS. TESTING WILL INCLUDE FUNCTIONAL TESTS OF ENGINE COMPONENTS, THRUST VECTOR CONTROL (TVC) SYSTEMS, AVIONICS, INSTRUMENTATION, AND POWER SYSTEMS ON THE LRBs. SIMILAR TESTING OF ET SYSTEMS CURRENTLY PERFORMED IN THE VAB HIGH BAYS WILL ALSO BE PERFORMED.

THE CONCEPT OF A CONTROL ROOM IN THE HPF SEPARATE FROM THE LCC FIRING ROOM IS RECOMMENDED PRIMARILY BECAUSE IT WOULD SUPPORT PARALLEL SHUTTLE PROCESSING AND LRB IMPLEMENTATION.

IT IS STRONGLY SUGGESTED THAT LPS-2 BE UTILIZED TO SPECIFY AND PROVISION FOR THE HPF CONTROL ROOM LPS EQUIPMENT. THIS IS RECOMMENDED BECAUSE OF INITIAL FABRICATION COST AND RECURRING/REPLACEMENT COST. IF THE LPS EQUIPMENT IS SEPARATELY SPECIFIED AND THEN LATER UPGRADED TO LPS 2, A PROCESSING SCHEDULE IMPACT AND ADDED COST WILL BE EXPERIENCED.

ET LRB HPF CONTROL ROOM



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ET / LRB .IPF CONCLUSIONS

- PROCESSING ET / LRB OFFLINE-INDEPENDENT OF INTEGRATED STS FLOW
- ACTIVATION OF FACILITY WILL NOT IMPACT ON-GOING OPERATIONS
- PROCESSING OUT OF VAB SAFETY ZONE
- ET GROUND UMBILICAL CARRIER PLATE (GUCP) INSTALLATION IN THE HPF WILL REQUIRE NEW GSE, PROCEDURES AND ET TRANSPORTER MOD

VAB HIGH BAY 3 - INTEGRATION

THE MMC LO2/RP1 PUMP-FED BOOSTER (AS A SMALL LRB) AND THE GDSS LO2/LH2 (AS A LARGE LRB) WERE CHOSEN TO EVALUATE THE VAB IMPACTS AND DESIGN SOLUTIONS. OTHER BOOSTER CONCEPTS WOULD FALL WITHIN THE RANGE OF DELTAS (DIFFERENCES).

THE LRB WILL BE LIFTED AND STACKED ON THE MLP HOLD DOWN SYSTEM. THE ATTACH STRUT LOCATIONS WILL BE THE SAME AS FOR THE SRB's. THEREFORE, EXISTING SRB ACCESS PLATFORMS CAN BE MODIFIED FOR DUAL CAPABILITY.

ONLY THREE LRB AREAS REQUIRE ACCESS: FORWARD, INTERTANK, AND AFT SKIRT: THE STRUCTURAL INTEGRITY OF THE EXISTING ENTENSIBLE PLATFORMS WILL BE AFFECTED BY THE MODIFICATIONS REQUIRED TO CLEAR THE ENVELOPE OF THE LRB. EACH FLOOR LEVEL WILL BE ANALYZED ON A CASE-BY-CASE BASIS. THE LRB CONCEPT CHOSEN WILL DETERMINE THE EXTENT OF IMPACT ON THE STRUCTURAL MEMBERS.

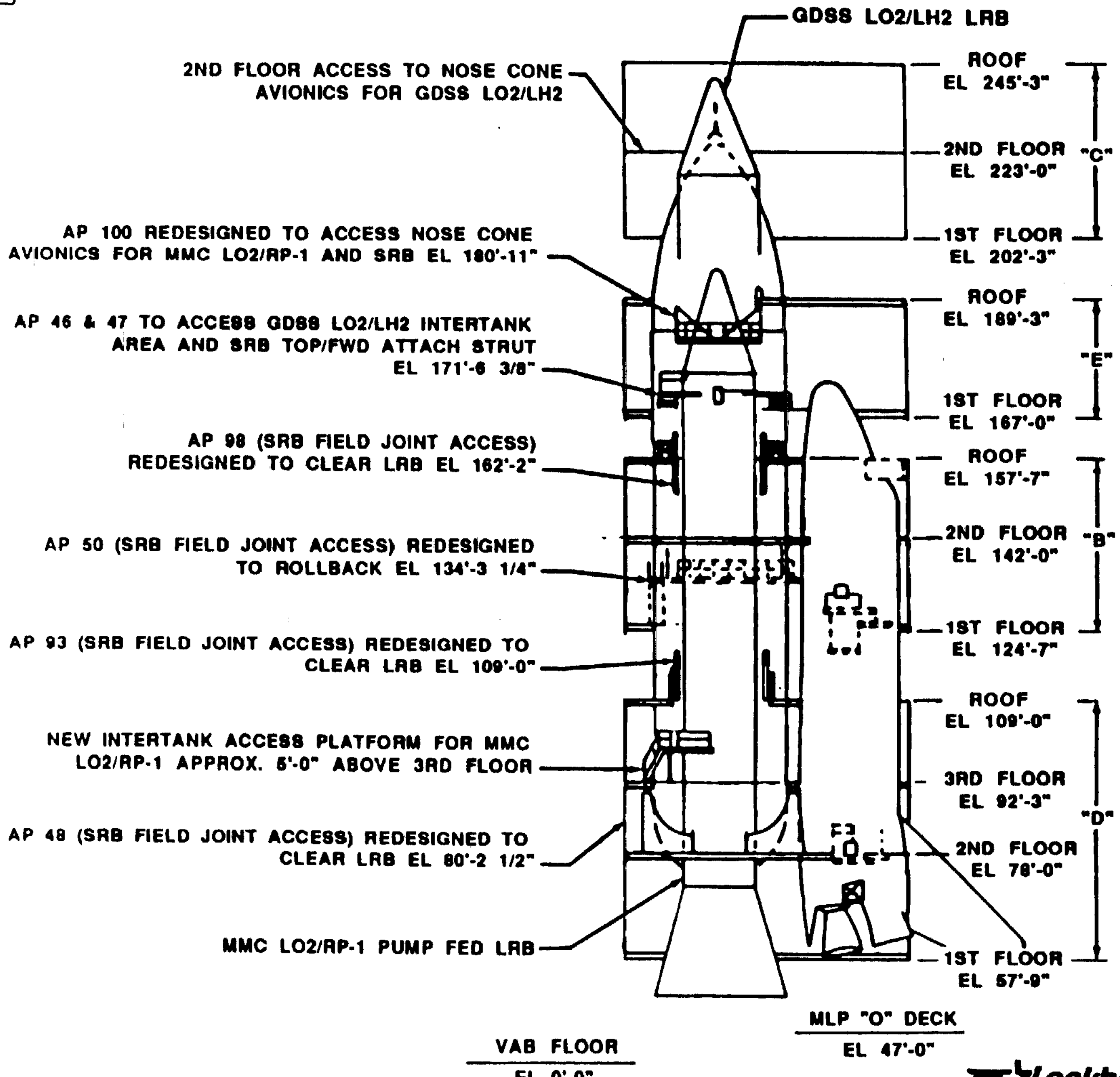
LRB ACCESS REQUIREMENTS							
	MMC		GDSS				
	LO2/RP-1 PUMP-FED	LO2/RP-1 PRESS-FED	LO2/RP-1 PUMP-FED	LO2/RP-1 PRESS-FED	LO2/LH2	LO2/CH4	LO2/LH2 [illegible]
BOOSTER DIAMETER	16.3'	16.2'	14.1'	18.6'	16.2'	16.0'	17.7'
HEIGHT	164.9'	182.7'	140.6'	195.7'	190.6'	150.8'	180.6'
ENGINE LEVEL ACCESS (REF. MLP ▽ DECK)	MLP ▽	MLP ▽	MLP ▽	MLP ▽	MLP ▽	MLP ▽	MLP ▽
INTERTANK AREA (EL ABOVE MLP ▽ DECK)	66.7'	68.3'	60.2'	81.6'	126.3'	64.4'	111.6'
FWD AREA (EL ABOVE MLP ▽ DECK)	120.6'	130.7'	120.6'	173.3'	166.4'	120.7'	144.0'
℄ LRB TO ℄ ET	27'-6"	28'-9-1/2"	21'-10"	27'-3-1/2"	27'-10-1/2"	27'-3-1/2"	23'-7-1/2"

LRB Access Requirements.

ALL EXISTING SRB ACCESS REQUIREMENTS WILL BE REVIEWED TO ENSURE THAT THE NEW MODIFICATIONS FOR LRB WILL NOT ELIMINATE THE ABILITY TO PERFORM THE REQUIRED OPERATIONAL TASKS.

AS STATED IN THE GROUNDRULES, THE MODIFICATION OF HIGH BAY 3 TO SUPPORT BOTH LRB's AND SRB's WILL NOT COMMENCE UNTIL HIGH BAY 4 IS OPERATIONAL FOR PROCESSING WITH LRB/SSVs. THIS SCENARIO WILL HAVE THE LEAST IMPACT ON THE ON-GOING FLIGHT SCHEDULE, SINCE SRB FLIGHTS WILL THEN BE BELOW SEVEN PER YEAR AND CAN BE SUPPORTED BY HIGH BAY 1 ONLY.

ACCESS REQUIREMENTS HB-3



VAB HIGH BAY LRB/SSV ROLLOUT CLEARANCES

AN EVALUATION STUDY WAS CONDUCTED ON VAB HIGH BAY 3 PLATFORMS AND VAB HIGH BAY 3 AND 4 DOORS FOR LRB/ET/ORBITER EXIT CLEARANCES FROM THE VAB.

IMPACTS TO HIGH BAY 3 PLATFORMS

PLATFORMS AT LEVELS D, B, E, AND C IN HIGH BAY 3 RETRACT OR FLIP UP TO ALLOW SRB/ET/ORBITER STACK CLEARANCE WHEN EXITING THE HIGH BAY.

PLATFORMS AFFECTED FOR THE MMC LO_2/RP1 PUMP-FED VEHICLE INCLUDE:

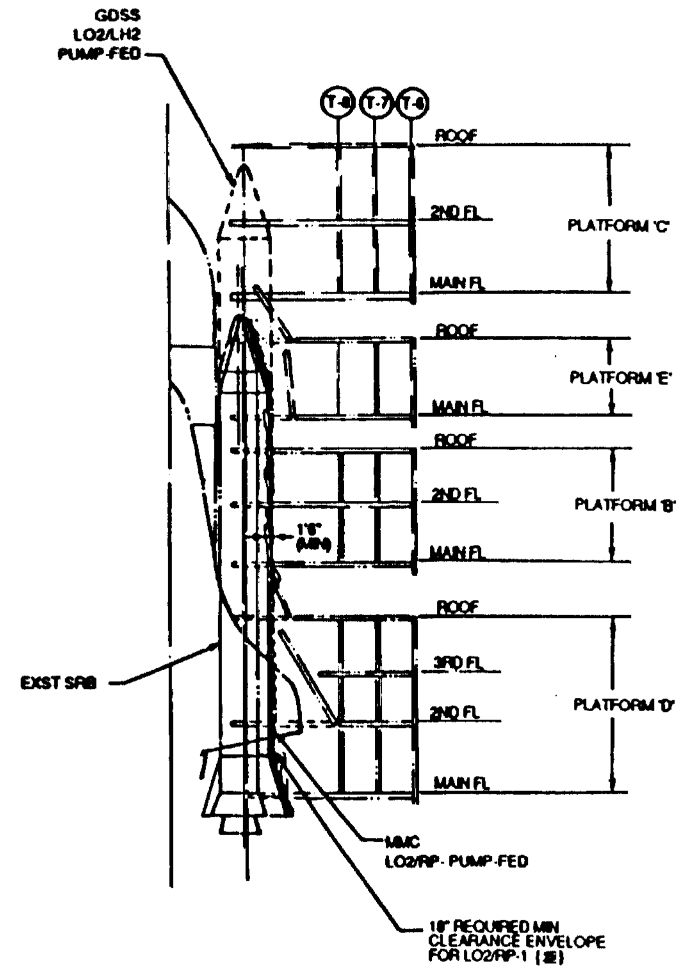
A. ROOF AND MAIN PLATFORMS OF LEVEL D
B. MAIN, SECOND, AND ROOF PLATFORMS OF LEVEL B
C. MAIN PLATFORM OF LEVEL E

THE PLATFORMS NOT AFFECTED INCLUDE:

A. SECOND AND THIRD PLATFORMS OF LEVEL D
B. ROOF PLATFORM OF LEVEL E
C. MAIN, SECOND, AND ROOF PLATFORMS OF LEVEL B

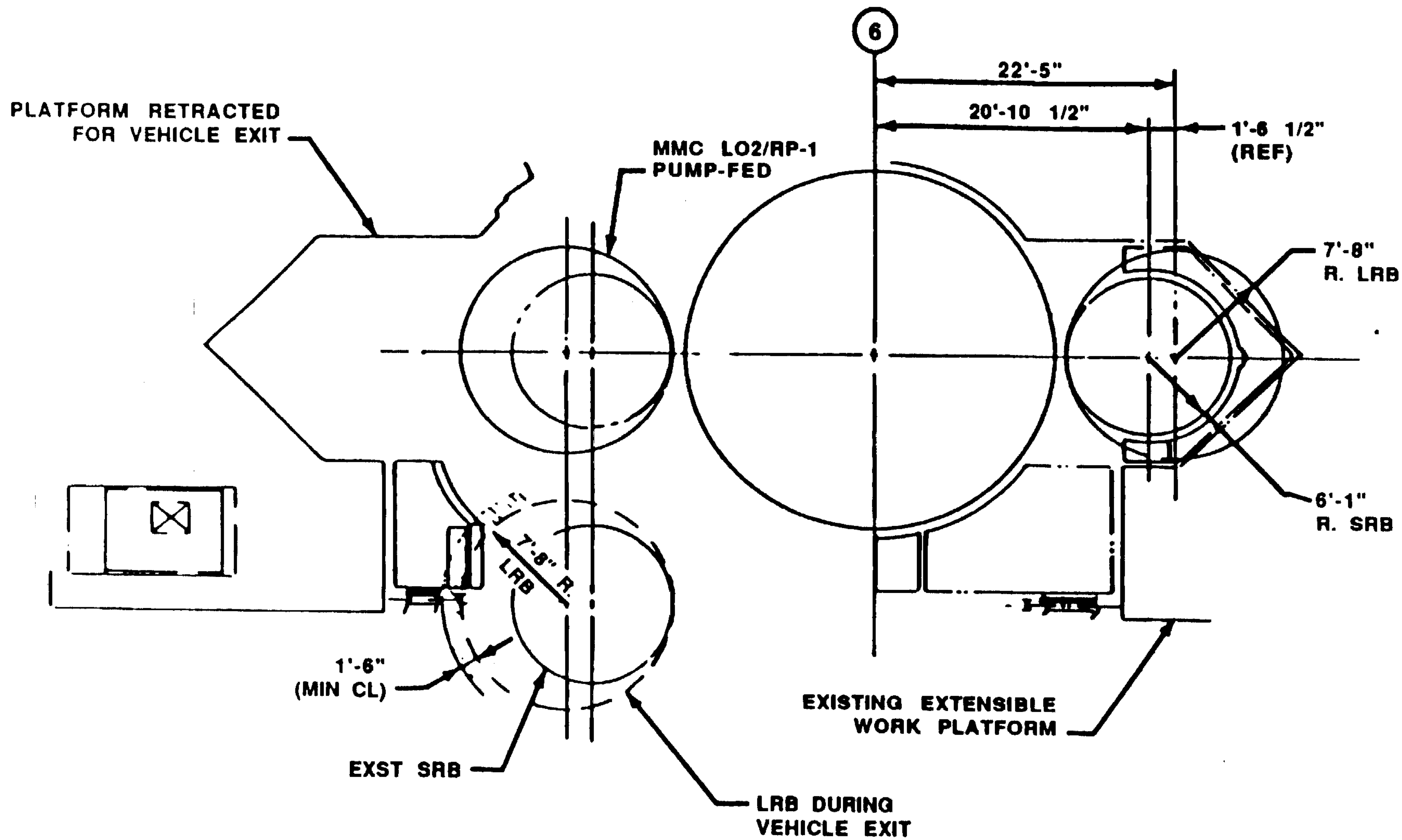
VAB DOOR EXIT CLEARANCE

VAB EXIT DOOR WIDTH FOR SRB/ET/ORBITER STACK CLEARANCE IS 71 FT 1 INCH. DOOR CLEARANCES HAVE BEEN EVALUATED FOR SEVEN CASES. ALL SELECTED LRB CONFIGURATIONS WILL PROVIDE ADEQUATE VAB DOOR CLEARANCES.



Exit Clearance With Extensible Work Platforms Retracted.

HB-3 PLATFORM INFRINGEMENT (TYPICAL)



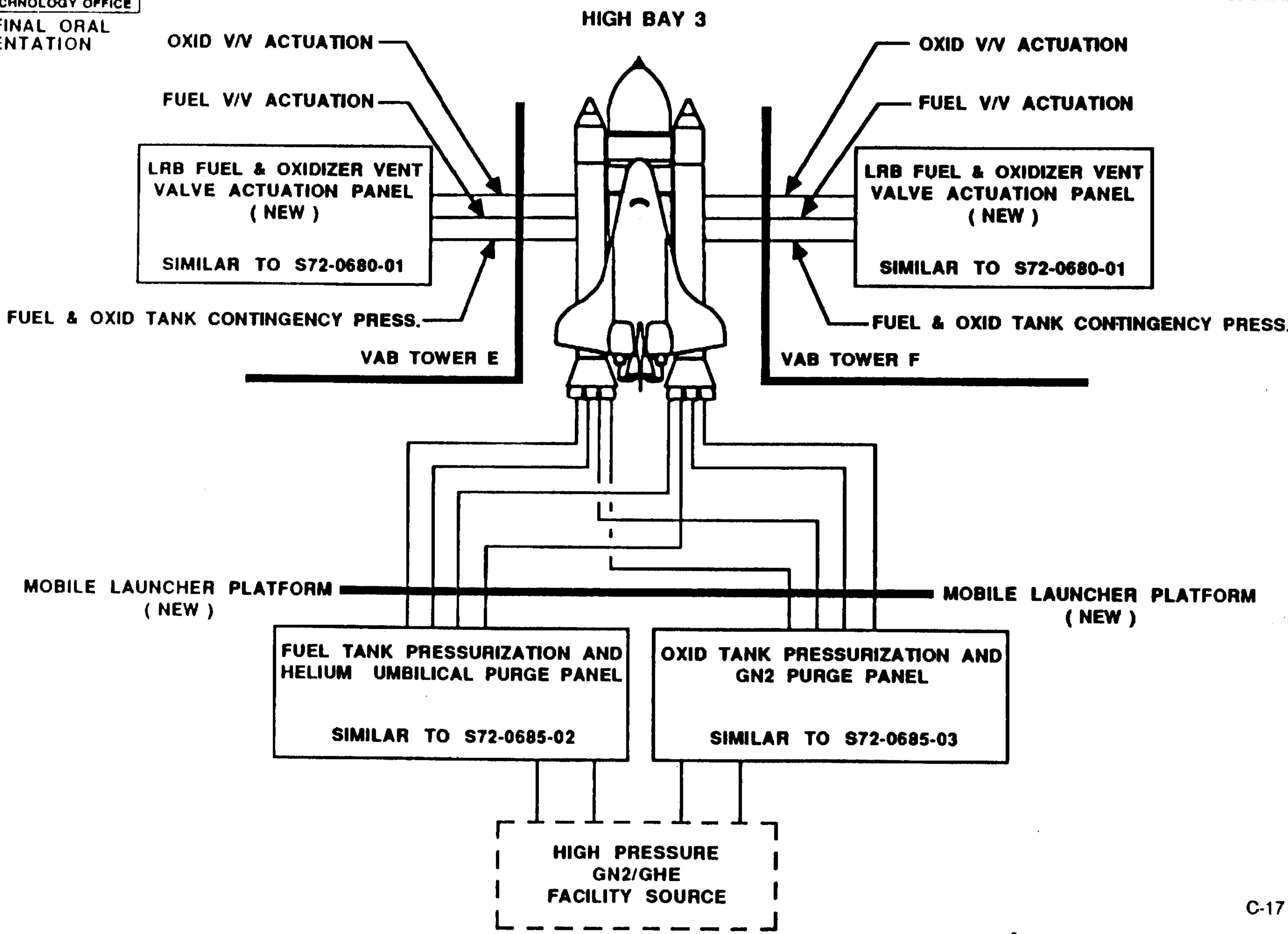
LRB INTEGRATION FLUID GSE FOR HIGH BAY 3 AND HIGH BAY 4

THE INTEGRATION PROCESSING GROUND SUPPORT EQUIPMENT FOR THE LIQUID ROCKET BOOSTERS WILL CONSIST OF EQUIPMENT TO SUPPORT TANK MONITORING, CONTINGENCY PRESSURIZATION, VENT VALVE ACTUATION, AND LRB ENGINE LEAK CHECK OPERATIONS. THE BASELINE REQUIREMENTS FOR LRB SERVICING ARE SIMILAR TO THE ET PROCESSING OPERATIONS PERFORMED IN HIGH BAY 3 OF THE VAB. A NETWORK OF SIMILAR PNEUMATIC PANELS ARE REQUIRED IN HIGH BAY 4 AND ON THE LRB-DEDICATED MLP.

THE PNEUMATIC SYSTEM WILL CONSIST OF A NETWORK OF PNEUMATIC PANELS THAT WILL REGULATE AND DISTRIBUTE FACILITY HELIUM AND NITROGEN GASES FOR PRESSURIZATION, MONITORING, SAFING AND MAINTENANCE OF TANK PRESSURES, VENT VALVE OPERATIONS, AND VARIOUS LEAK CHECKS.

THE EXISTING VAB FACILITY HELIUM AND NITROGEN HIGH PRESSURE REGULATION AND CONTROL SYSTEM CAN BE USED TO REGULATE AND DISTRIBUTE THE FACILITY GAS TO THE PNEUMATIC SUPPORT SYSTEM.

LRB GSE H 3 INTEGRATION CELL



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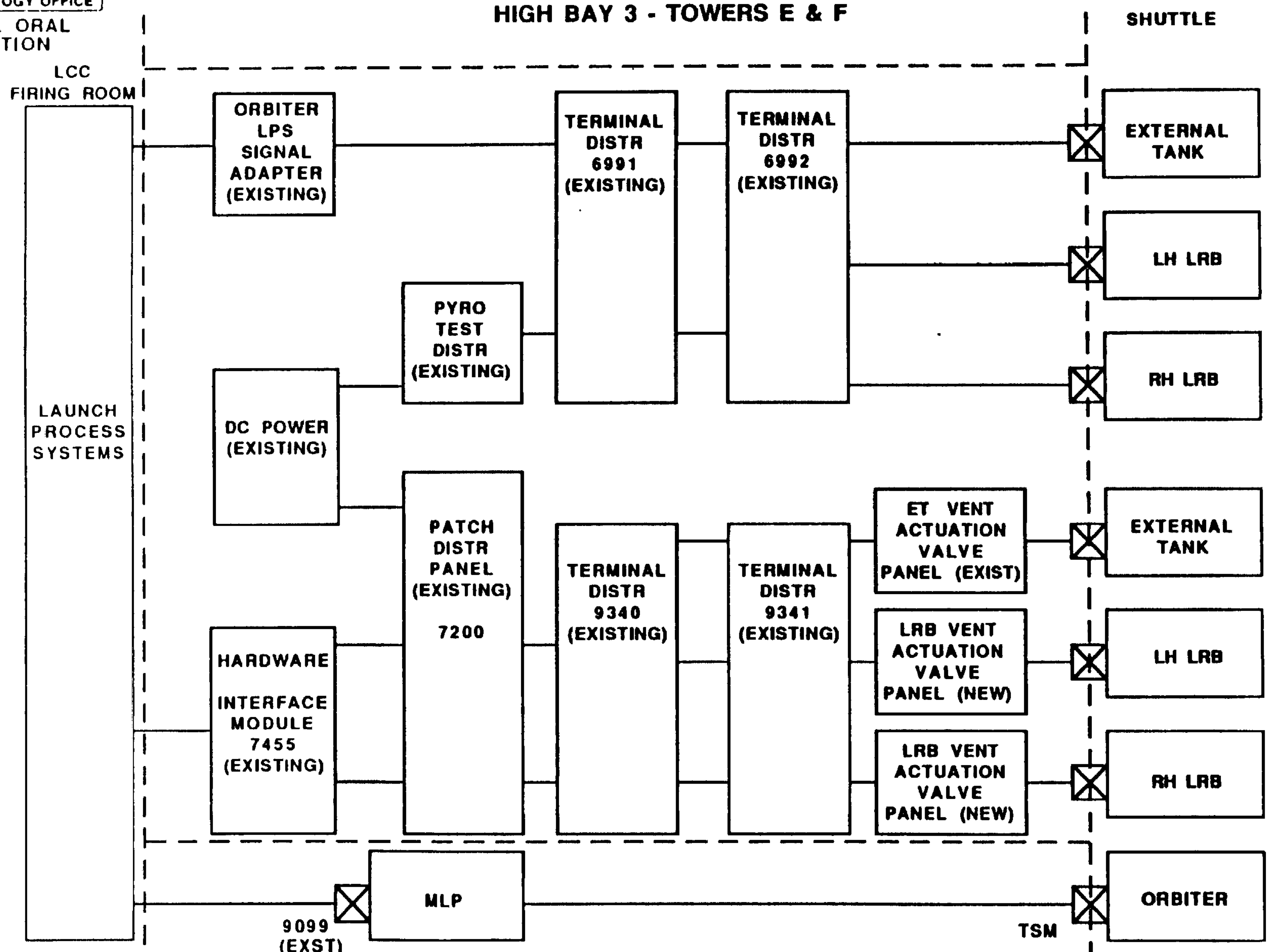

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VAB HIGH BAY 3 CONCLUSIONS

- PLATFORMS TO SUPPORT LRB WILL BE REQUIRED
- ALL LRB CONFIGURATIONS INFRINGE ON HIGH BAY 3 PLATFORMS DURING EXIT
- ALL PLATFORMS REQUIRE MODIFICATION FOR LRB DIAMETER
- NEW GSE FOR LRB REQUIRED

VAB HIGH BAY 4 - INTEGRATION

TO MEET A LAUNCH RATE OF THREE LRB's IN 1996 AND STILL MAINTAIN SRB LAUNCH PROCESSING OPERATIONS IN HIGH BAY 1 AND HIGH BAY 3, IT WILL BE NECESSARY TO CONVERT HIGH BAY 4 INTO AN LRB STACKING AND INTEGRATION CELL.

AT PRESENT HIGH BAY 4 IS USED AS A STORAGE AND CHECKOUT CELL FOR THE ET AND HAS A BACKUP CAPABILITY OF PROVIDING BUILDUP STANDS FOR THE SRB AFT SEGMENTS. NO PLATFORMS ARE AVAILABLE TO ACCESS THE ORBITER, LRB, OR ET. NEW PLATFORMS WILL BE BUILT.

	MMC		GDSS				
	LOX/RP-1 PUMP FED	LOX/RP-1 PRESSURE FED	LOX/RP-1 PUMP FED	LOX/RP-1 PRESSURE FED	LOX/CH 4	LOX/LH 2	
BOOSTER DIAMETER	15.3	18.2'	14.1'	16.0'	18.0'	18.2'	
HEIGHT	150.9	182.7'	148.8'	186.7'	150.1'	191.0'	
ENGINE LEVEL ACCESS	EL 47'-0"	EL 47'-0"	EL 47'-0"	EL 47'-0"	EL 47'-0"	EL 47'-0"	
INTERTANK ACCESS	PLATFORM D 3RD FLOOR EL 92'-25"	PLATFORM D 3RD FLOOR EL 92'-25"	PLATFORM D 3RD FLOOR EL 92'-25"	PLATFORM B MAIN FLOOR EL 124'-7"	PLATFORM D ROOF EL 109'-0"	AP 46/47 EL 170'-4"	
FWD ACCESS	PLATFORM E AP 46/47 EL 171'-4 3/8"	PLATFORM E AP 46/47 EL 171'-4 3/8"	PLATFORM E AP 46/47 EL 171'-4 3/4"	PLATFORM C MAIN FLOOR EL 202'-3"	PLATFORM E AP 46/47 EL 171'-4 3/8"	PLATFORM C MAIN FLOOR EL 202'-3"	

ITEMS (ACCESS REQUIREMENTS)	ORBITER	EXTERNAL TANK	ACCESS LEVEL FROM HB 4
AFT FUSELAGE ACCESS DOOR	✓	—	3RD FLOOR PLATFORM LEVEL 'D' • AP [illegible]
AFT ATTACH POINT	✓	✓	3RD FLOOR PLATFORM LEVEL 'D'
MID FUSELAGE AND PREFLIGHT UMBILICALS	✓	—	MAIN FLOOR PLATFORM LEVEL 'B' • AP [illegible]
INTERTANK ACCESS	—	✓	MAIN FLOOR PLATFORM LEVEL 'E'
ORBITER ACCESS ROOM • STAR TRACKER DOOR	✓	—	ROOF PLATFORM LEVEL 'B' • AP [illegible]
FWD ATTACH POINT	✓	✓	1ST FLOOR PLATFORM LEVEL 'E'
ENGINE SERVICE PLATFORM	✓	—	USE EXISTING ESP

TO CONVERT HIGH BAY 4 INTO AN STS INTEGRATION FACILITY, THE PRESENT ET CHECKOUT FUNCTION WILL BE RELOCATED TO THE NEW ET/LRB HORIZONTAL PROCESSING FACILITY. THE SRB BUILDUP STANDS WILL BE DISMANTLED AND RELOCATED TO HIGH BAY 2.

THREE OF THE FOUR MLP PEDESTALS IN HB-4 HAVE BEEN DISMANTLED AND STORED IN THE MLP PARKSITE AREA. THESE ARE NOT IN THE BEST SHAPE STRUCTURALLY AFTER BEING IN OPEN STORAGE FOR A NUMBER OF YEARS. NEW PEDESTALS WILL BE REQUIRED.

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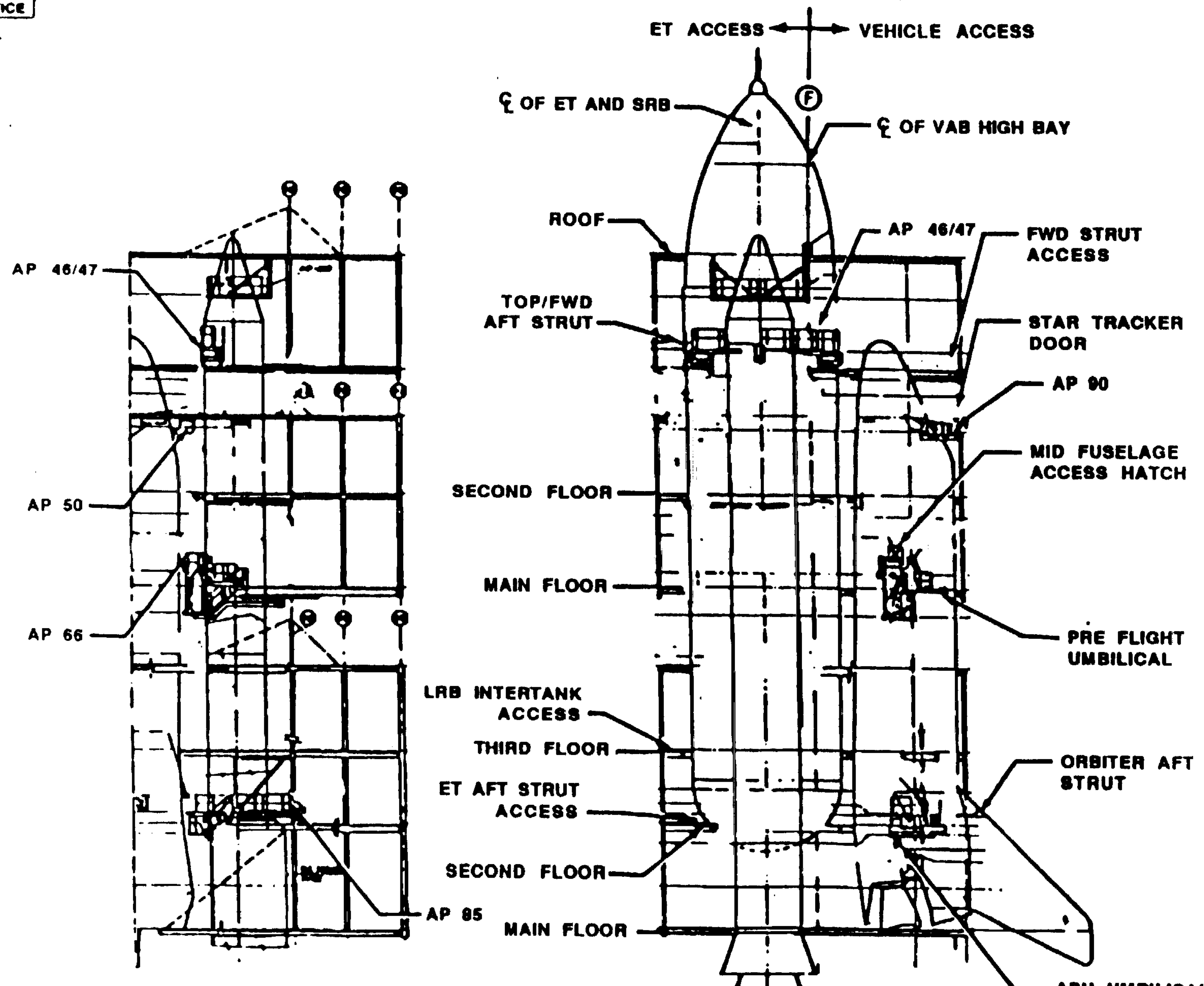
ACCESS REQUIREMENTS HB-4



REACTIVATION OF CRAWLERWAY TO VAB HIGH BAY 4

A LARGE SECTION OF CRAWLERWAY REQUIRES REFURBISHMENT FOR HB-4 USE. IT STARTS NORTHWEST OF THE OMRF WHERE IT JOINS THE EXISTING CRAWLERWAY AND PROCEEDS SOUTH AND EAST TO THE NORTHWEST CORNER OF THE VAB (HIGH BAY 4).

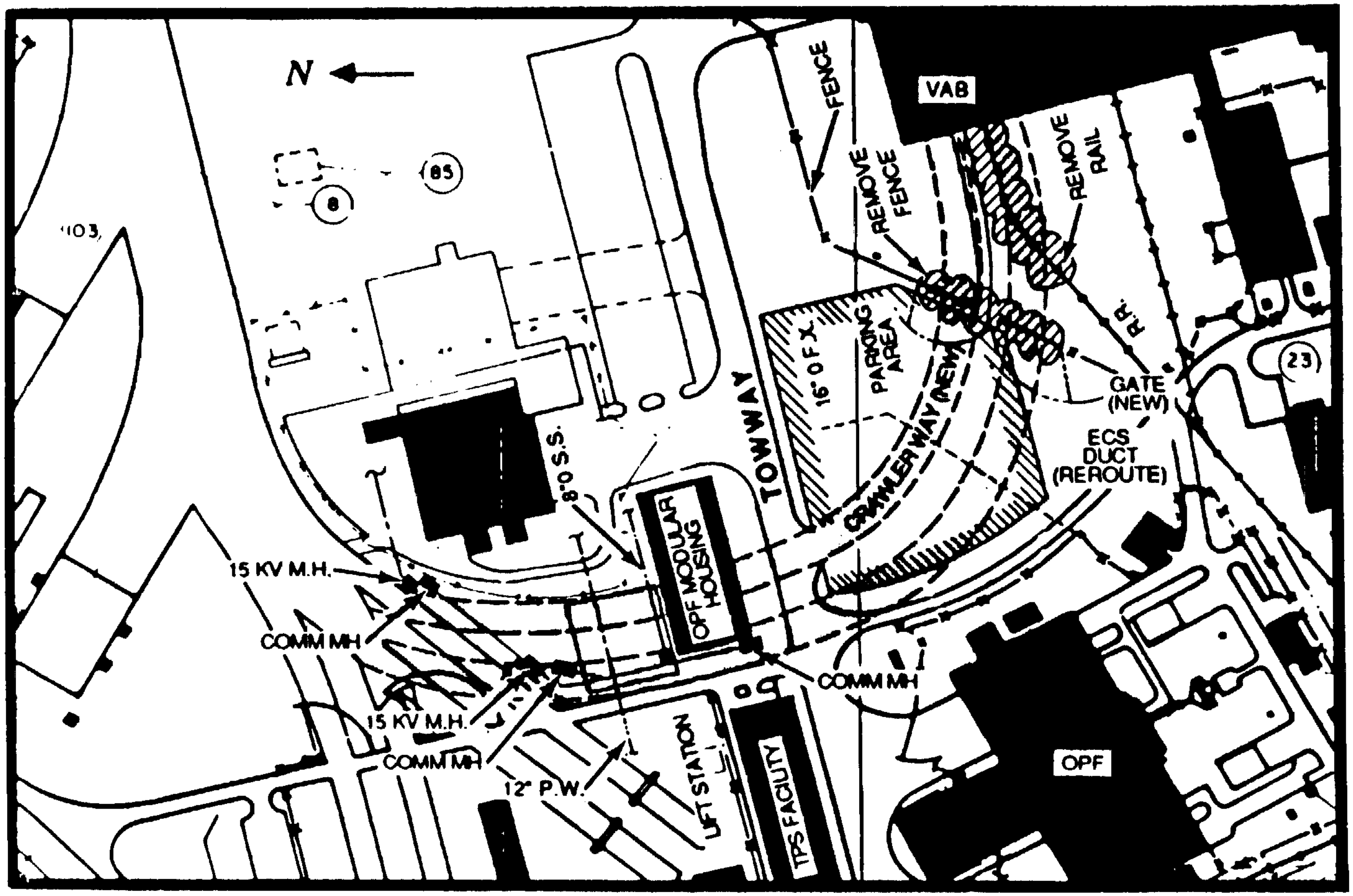
THE OPF MODULAR COMPLEX WILL REQUIRE RELOCATION. A SECTION OF THE ORBITER TOWWAY FROM THE OPF TO THE VAB WILL HAVE TO BE MODIFIED TO BE COMPATIBLE WITH BOTH THE ORBITER AND CRAWLER. CURRENTLY, A PARKING AREA IS LOCATED EAST OF THE OPF MODULAR COMPLEX AND A PORTION OF THIS MUST BE DELETED: A SECTION OF RAILROAD WILL HAVE TO BE REROUTED: AND A SECTION OF FENCE CROSSING THE CRAWLERWAY SITE WILL BE RELOCATED. VARIOUS UNDERGROUND UTILITY LINES AND MANHOLES WILL REQUIRE RELOCATION. THE OMRF ECS DUCT AND CHILL WATER PIPING FROM THE VAB, WHICH RUNS ALONG THE WEST SIDE OF THE PARKING AREA AND UNDER THE TOWWAY MUST BE RELOCATED.

REACTIVATION REQUIREMENTS

THE OLD CRAWLERWAY BED MUST BE PREPARED WITH A NEW COMPACTED BASE COURSE, AS REQUIRED. A BITUMINOUS PRIME COAT SHOULD BE APPLIED AND THE BED RESURFACED WITH GRAVEL, AND CURBS ADDED.

UTILITY AND COMMUNICATIONS LINES BENEATH THE CRAWLERWAY WILL REQUIRE RELOCATION AND ADEQUATE PROTECTION AGAINST CRAWLER LOADS. NEW COMMUNICATION AND ELECTRICAL MANHOLES ARE REQUIRED. THE ECS CROSSCOUNTRY DUCT CAN BE REROUTED ADJACENT TO THE CRAWLERWAY AND NEW GATES INSTALLED WHERE THE FENCE CROSSES THE CRAWLERWAY.

VAB HB-4 CRAWLERWAY REACTIVATION



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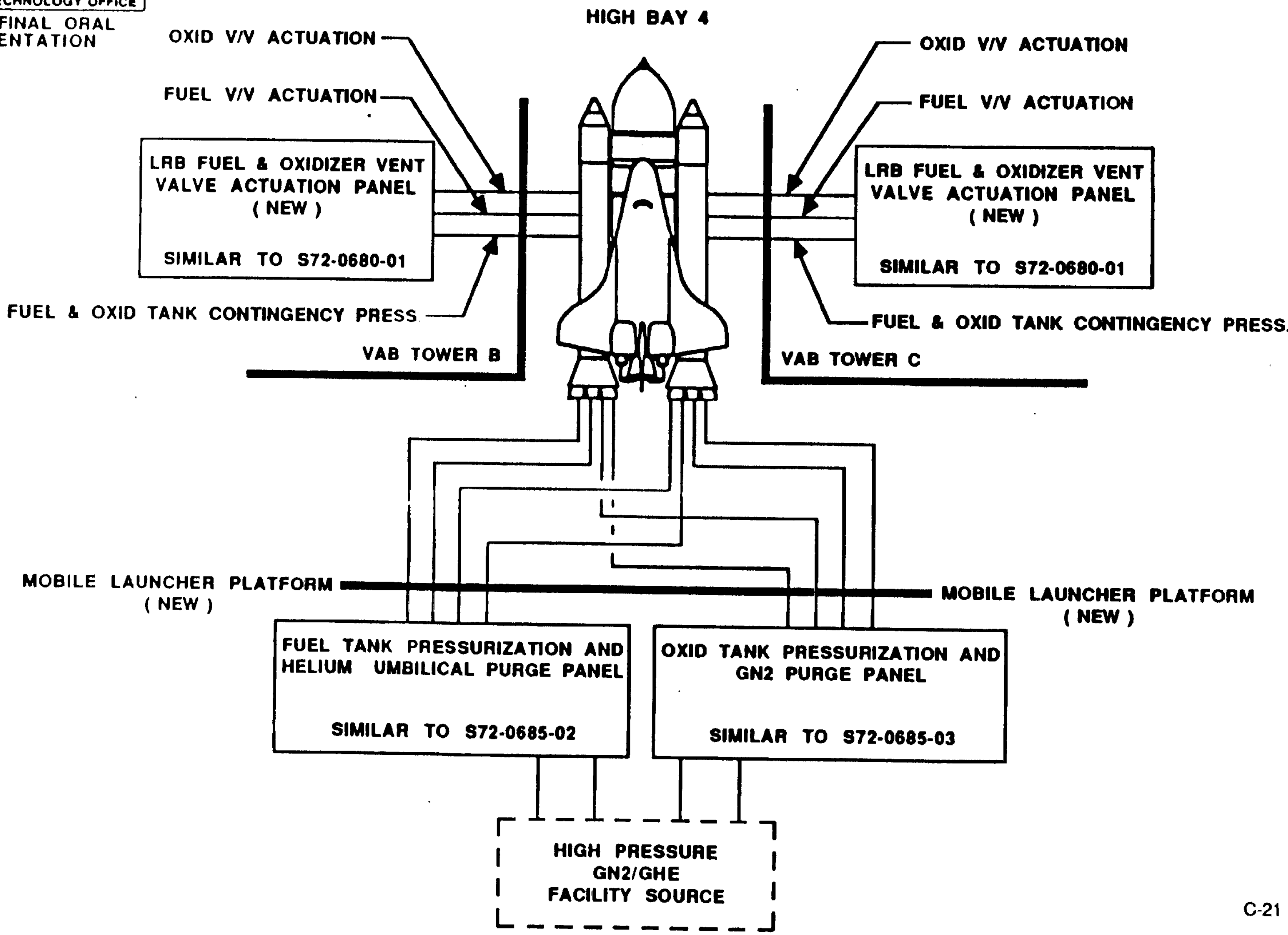
LRB GSE H B-4 INTEGRATION CELL



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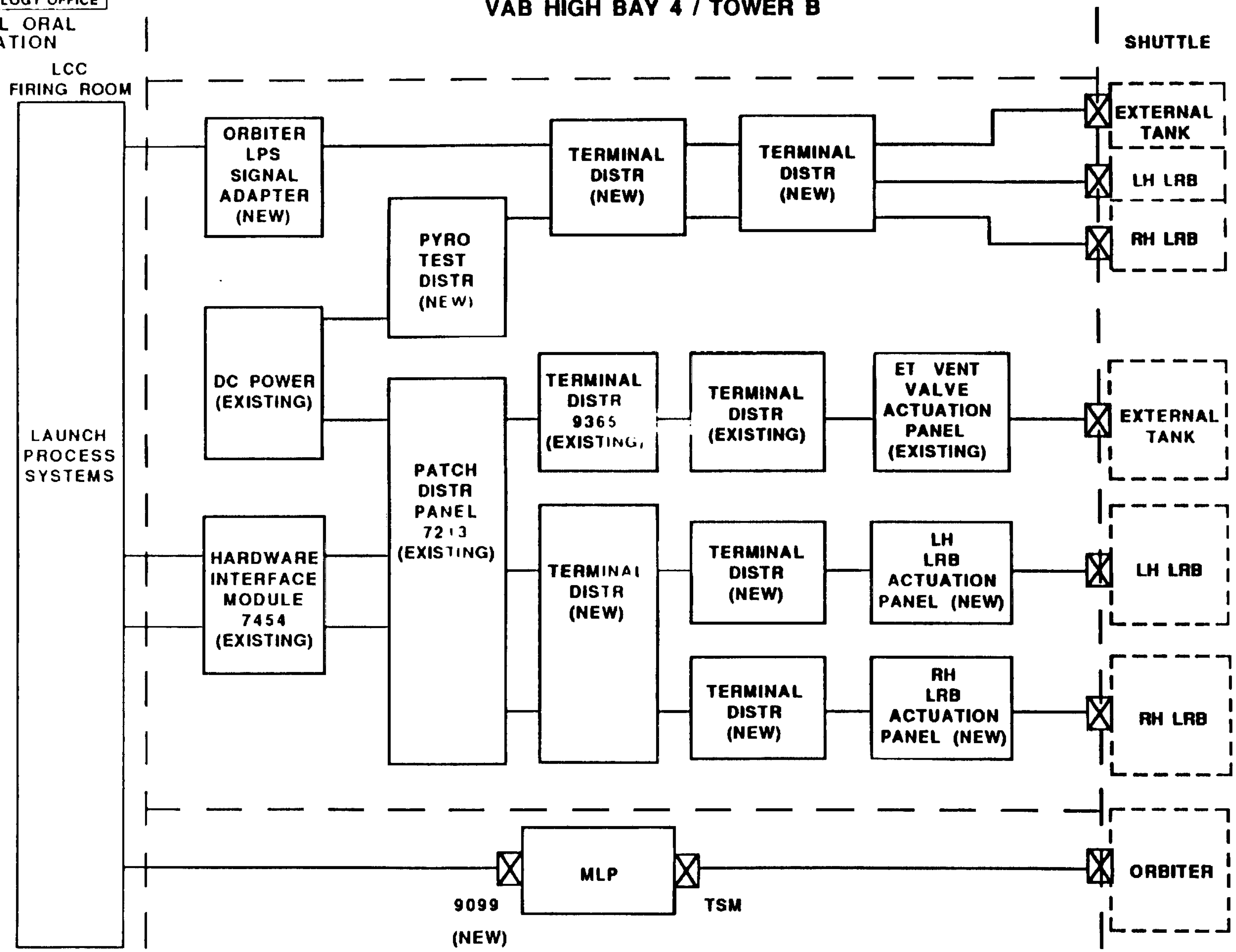
LRB ELECTRICAL GSE

VAB HIGH BAY 4 / TOWER B



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- NEW PLATFORM STRUCTURES FOR ORBITER / ET / LRB REQUIRED
- ET PROCESSING MOVED TO HPF
- SRB WORK STANDS MOVE TO HIGH BAY 2
- CRAWLERWAY MUST BE REACTIVATED
- GSE FOR ORBITER / ET / LRB REQUIRED

MLP EXHAUST HOLES (MMC)

MMC LOX/RP1 PUMP-FED CONFIGURATION IMPACTS. THE IMPACTS OF THIS CONFIGURATION ON THE EXISTING MLP STRUCTURAL DESIGN ARE SHOWN IN THE FIGURE.

IN THE PLAN VIEW THE IMPACTS ON EXISTING GIRDERS AS WELL AS THE MODIFICATIONS REQUIRED TO RELOCATE GIRDERS G-22, G-23, G-24, AND G-25 CAN BE SEEN. THE FIGURE SHOWS THE LRB EXHAUST HOLE WIDTH CHANGES REQUIRED, AND THE EXHAUST HOLE LENGTH.

COMPARISONS BETWEEN PUMP-FED AND PRESSURE-FED CONCEPTS HAVE BEEN DEVELOPED. EXHAUST HOLE SIZES, GIRDER LOCATION CLEARANCES, AND IMPACTS HAVE BEEN IDENTIFIED. FOR EXAMPLE: GIRDER G-20 GOES AWAY TOTALLY IN THE PRESSURE-FED CONCEPT.

G-20 IS THE MAIN GIRDER OF MLP STRUCTURAL FRAMINGS. ANY RELOCATION NORTH OF THE PRESENT POSITION WOULD MAKE THE SSME EXHAUST HOLE SMALLER. RELOCATING G-20 TOWARD THE SOUTH FROM ITS PRESENT POSITION WOULD GIVE IT HEAVY EXPOSURE TO LRB ENGINE BLAST. RESOLUTION OF THIS DILEMMA IN THE NEW MLP DESIGN WILL BE A CHALLENGE.

TO MEET THE GROUNDRULES, ALL STRUCTURAL DESIGNS REQUIRE A MINIMUM OF THREE ENGINE NOZZLE DIAMETERS CLEARANCE FROM ANY FLAT SURFACE, AS STATED IN PARAGRAPH 3.5 OF "STANDARD FOR FLAME DEFLECTOR DESIGN (KSC-STD-Z-0012)."

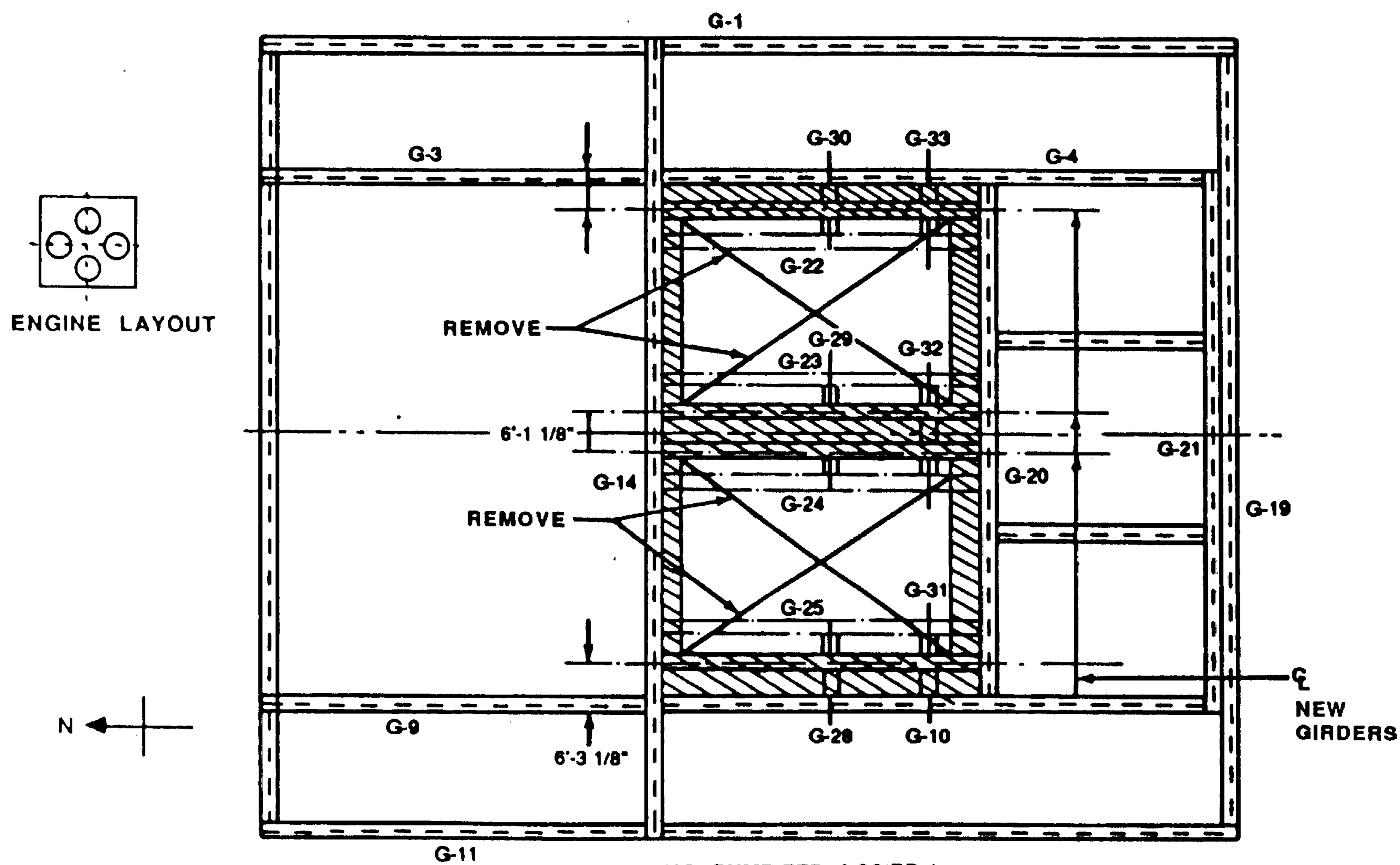
RELOCATING GIRDER G-20 WOULD SERIOUSLY AFFECT THE STRUCTURAL INTEGRITY OF THE EXISTING MLP, AND TOTAL OMISSION IS NOT FEASIBLE. DESIGN FEASIBILITY OF PROVIDING A NEW GIRDER IN THE REDESIGN IS QUESTIONABLE.

MODIFICATION OF MLP-1 & 2 FROM THE OLD APOLLO SYSTEM TOOK 5 YEARS EACH. ALL LRB MODIFICATIONS WOULD TAKE ABOUT THE SAME LENGTH OF TIME OR MORE IF PERMITTED BY DESIGN FEASIBILITY.

IT IS THEREFORE RECOMMENDED THAT A NEW MLP BE BUILD TO START THE LRB PROGRAM.

MLP EXHAU HOLE DEMOLITION

MMC LOX/RP-1 PUMP-FED



MMC PUMP-FED LO2/RP-1

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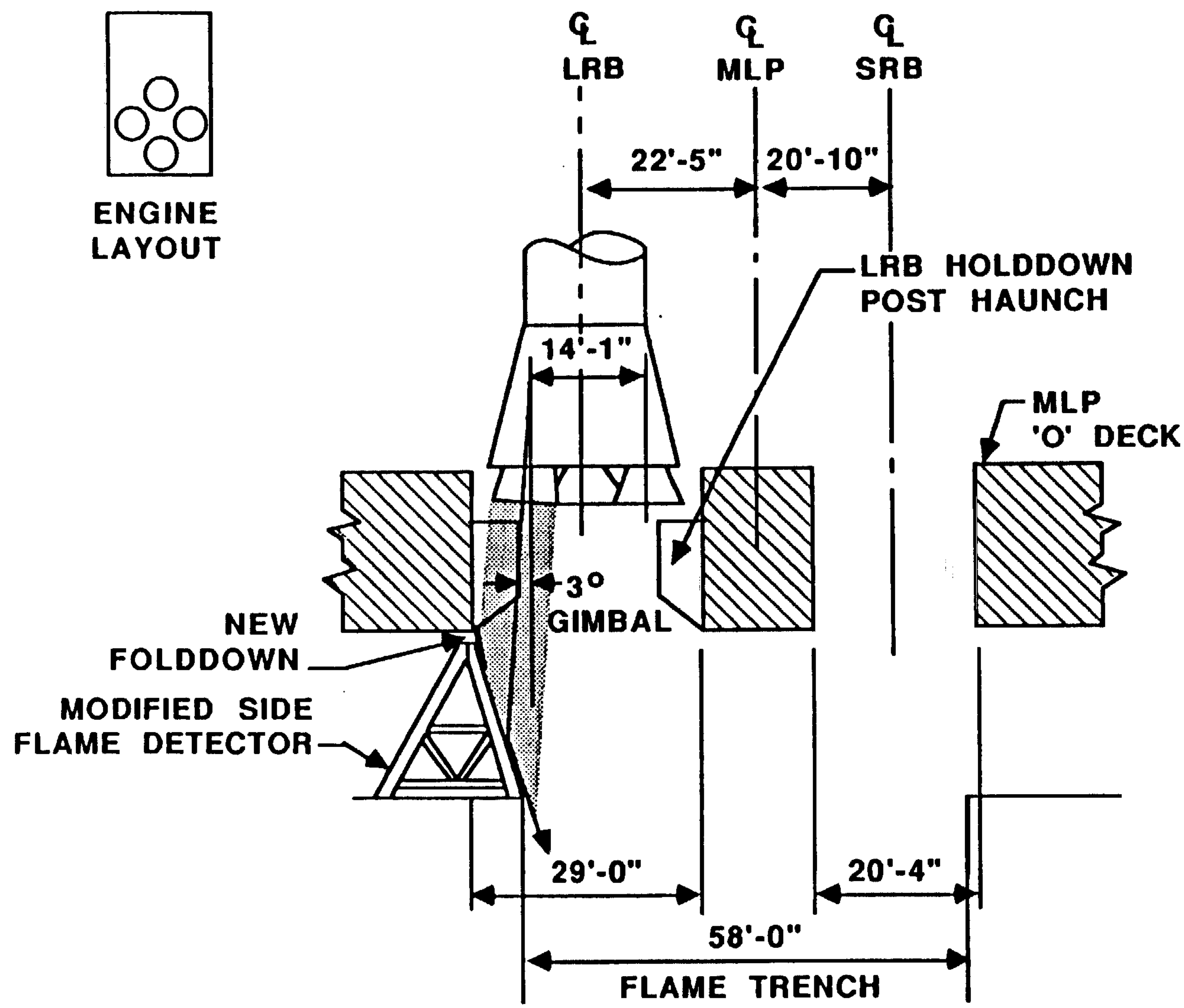
MLP EXHAUST HOLE WALL FLAME IMPINGEMENT

MMC LOX/RP-1 PUMP-FED



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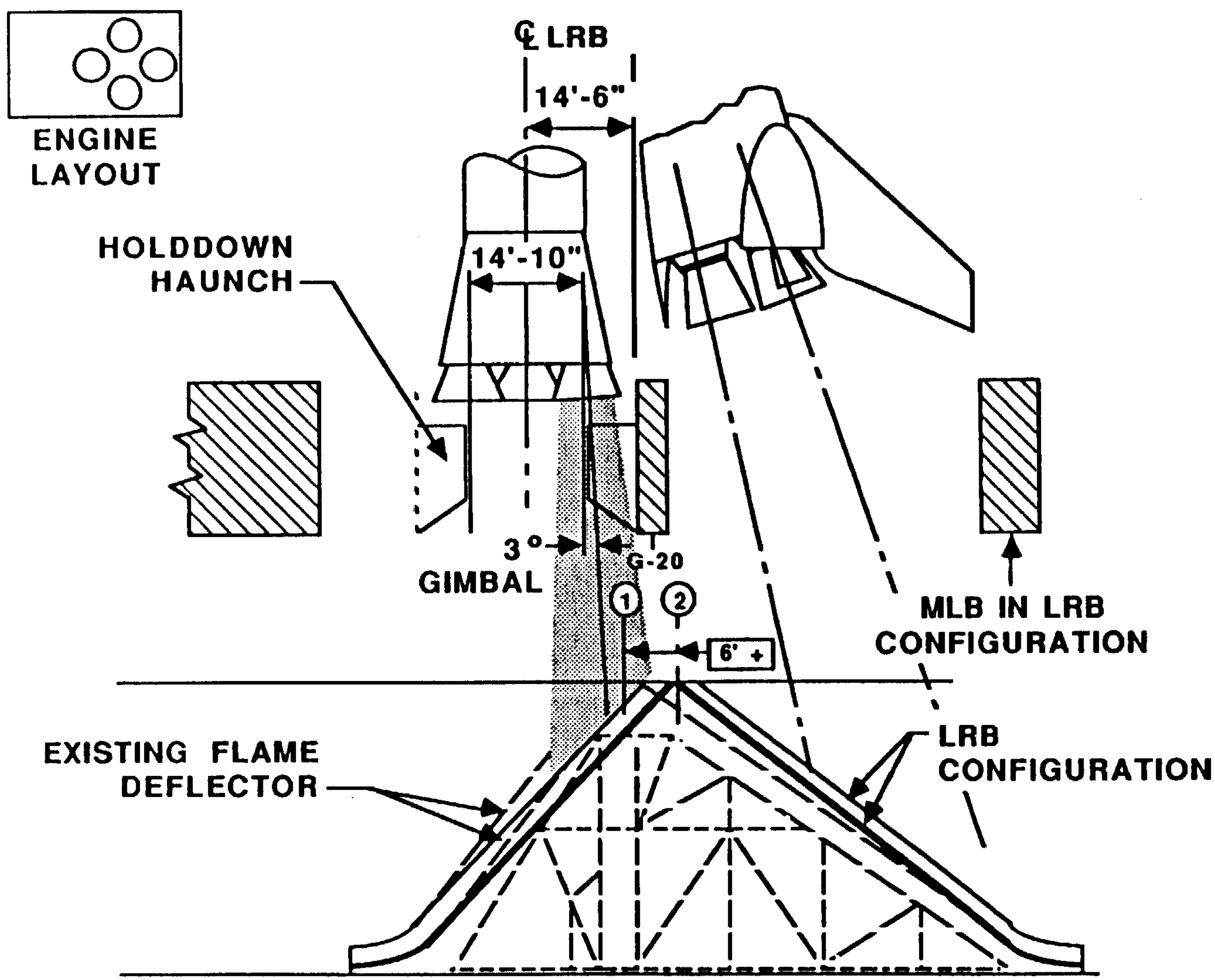
MMC LOX/RP-1 PUMP FED



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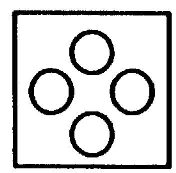
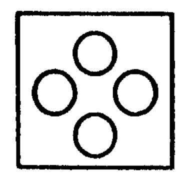
	LO2/RP-1 PUMP-FED	LO2/RP-1 PRESS-FED
BOOSTER DIAMETER	15'-3"	16'-2"
SKIRT DIAMETER	22'-11/4"	26"-0"
℄ LRB FROM ℄ ET	22'-5"	22'-9 1/2"
EXHAUST HOLE SIZE	29'-0" X 41"-4 1/4"	32'-0" X TBD
IMPACT TO G-20 AT 6° ENGINE GIMBAL	APPROX .8' CLEARANCE FROM BLAST SHIELD	NO CLEARANCE; RELOCATE
℄ G-10 TO RELOCATED G-25 AND G-4 TO RELOCATED G-2	6'-3 1/8"	3'-4 5/8"
℄ ET TO RELOCATED G-23 AND G-24	6'-1 1/8"	4"-11 5/8"
LOCATION OF NEW HOLDDOWN POST HAUNCHES	TBD	TBD
ENGINE LAYOUT		

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MLP EXHAUST HOLES (GDSS)

GDSS LOX/RP1 PUMP-FED CONFIGURATION IMPACTS. THE IMPACTS OF THIS CONFIGURATION ON THE EXISTING MLP STRUCTURAL DESIGN ARE SHOWN IN THE FIGURES.

THE PLAN VIEW THE IMPACTS ON EXISTING GIRDERS AS WELL AS THE MODIFICATIONS REQUIRED TO RELOCATE GIRDERS G-22, G-23, G-24, AND G-25. THE FIGURES SHOW THE LRB EXHAUST HOLE WIDTH REQUIRED, AND THE EXHAUST HOLE LENGTH. THIS FIGURE ALSO SHOWS THE NEW GIRDERS REQUIRED FOR SUPPORTING THE HOLDDOWN SYSTEM. THESE GIRDERS ARE LOCATED IN LRB EXHAUST HOLES AND WILL BE SUBJECTED TO LRB BLAST PRESSURE AND PROLONGED HIGH TEMPERATURES.

COMPARISONS HAVE BEEN MADE BETWEEN GDSS LOX/RP-1 PUMP-FED, LOX/LH2 AND LOX/CH4 CONCEPTS. THE SIZE OF EXHAUST HOLES, LOCATION OF GIRDERS, AND IMPACT TO EXISTING GIRDER G-20 CAN BE SEEN IN THE FIGURE.

G-20 IS THE MAIN GIRDER OF MLP STRUCTURAL FRAMINGS. ANY RELOCATION NORTH OF THE PRESENT POSITION WOULD MAKE THE SSME EXHAUST HOLE SMALLER. RELOCATING G-20 TOWARD THE SOUTH FROM ITS PRESENT POSITION WOULD GIVE IT HEAVY EXPOSURE TO LRB ENGINE BLAST.

TO MEET THE GROUNDRULES, ALL STRUCTURAL DESIGNS REQUIRE A MINIMUM OF THREE ENGINE NOZZLE DIAMETERS CLEARANCE FROM ANY FLAT SURFACE, AS STATED IN PARAGRAPH 3.5 OF "STANDARD FOR FLAME DEFLECTOR DESIGN (KSC-STD-Z-0012)."

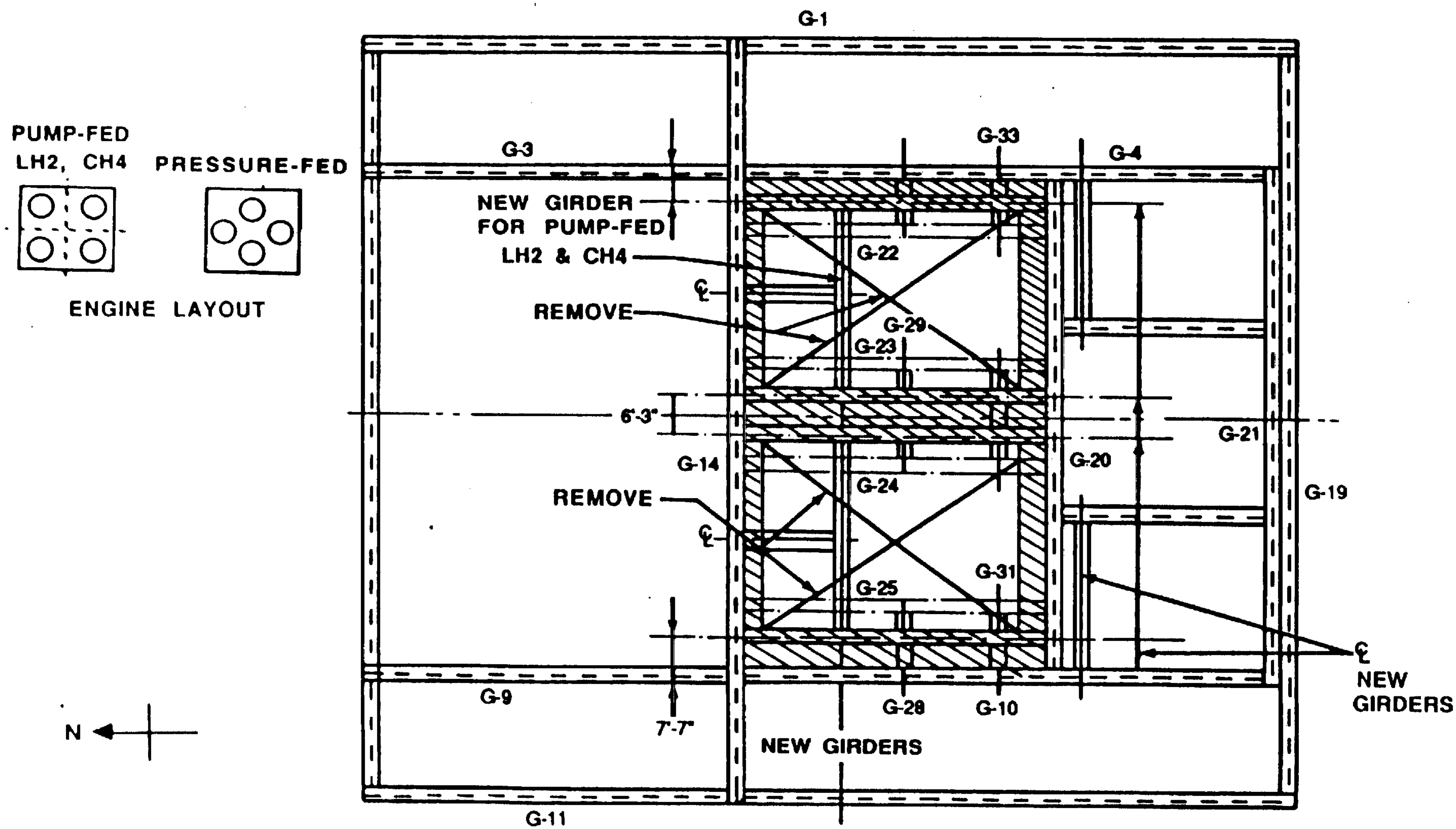
RELOCATING GIRDER G-20 WOULD SERIOUSLY AFFECT THE STRUCTURAL INTEGRITY OF THE MLP, AND TOTAL OMISSION IS NOT FEASIBLE. DESIGN FEASIBILITY OF PROVIDING A NEW GIRDER IN THE LRB EXHAUST HOLES MAY BE QUESTIONABLE.

MODIFICATION OF MLP-1 & 2 FROM THE OLD APOLLO SYSTEM TOOK 5 YEARS EACH. ALL LRB MODIFICATIONS WOULD TAKE ABOUT THE SAME LENGTH OF TIME OR MORE IF PERMITTED BY DESIGN FEASIBILITY.

IT IS THEREFORE RECOMMENDED THAT A NEW MLP BE BUILD TO START THE LRB PROGRAM.

MLP EXHAUST HOLE DEMOLITION

GDSS LOX/RP-1 PUMP-FED



GDSS PUMP-FED LO2/RP-1

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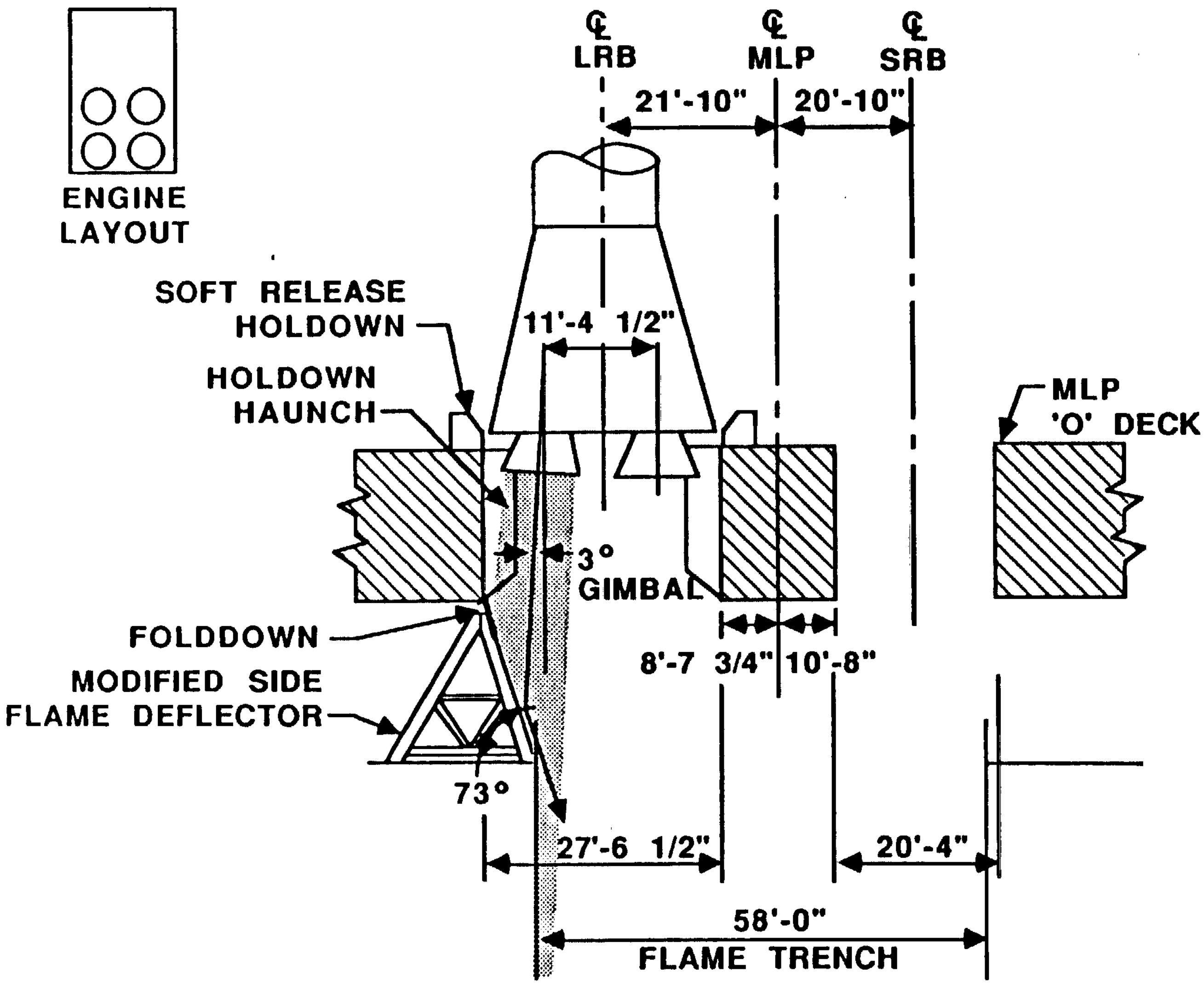
MLP EXHAUST HOLE WALL FLAME IMPINGEMENT

GDSS LOX/RP-1 PUMP-FED



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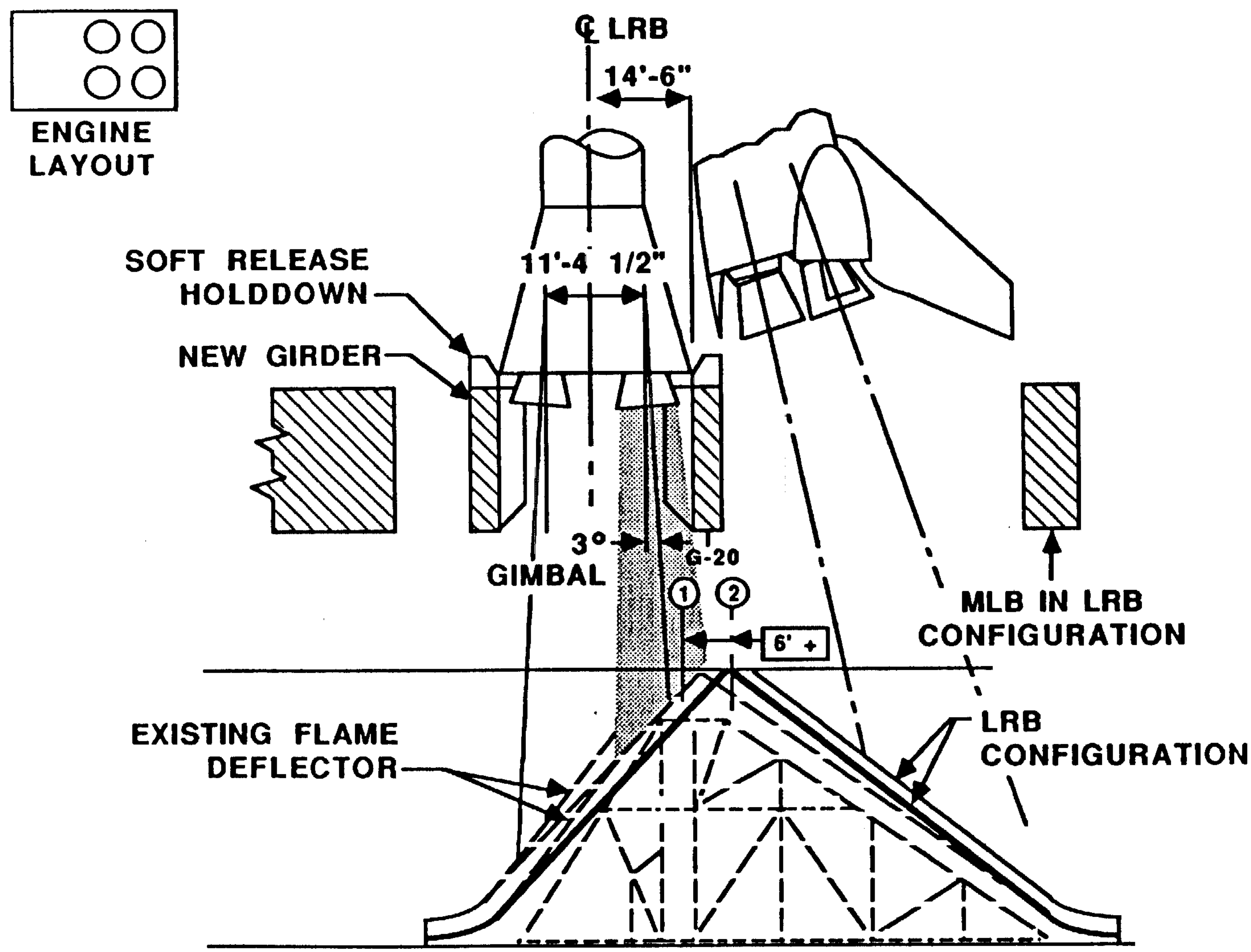
MLP COLUMN LINE G-20 FLAME IMPINGEMENT

GDSS LOX/RP-1 PUMP-FED



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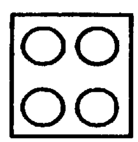
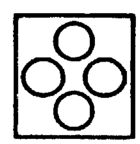
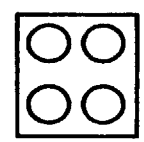
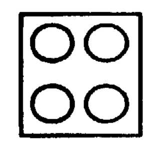
COMPARISONS BETWEEN GDSS CONFIGURATIONS

	LO2/RP-1 PUMP-FED	LO2/RP-1 PRESS-FED	LO2 / LH2	LO2 / CH4
BOOSTER DIAMETER	14'-1"	15'-0"	16'-2"	15'-0"
SKIRT DIAMETER	25'-11 1/8"	26"-9 1/2"	22"-3 1/2"	27'-3 1/4"
℄ LRB FROM ℄ ET	21'-10"	22'-3 1/2"	22'-10 1/2"	22'-3 1/2"
EXHAUST HOLE SIZE	41'-4 1/2" X 27'-6 1/4"	SAME	SAME	SAME
IMPACT TO GIRDER G-20	~2.5' CLEARANCE FROM BLAST SHIELD	NO CLEARANCE	~4.5' CLEARANCE FROM BLAST SHIELD	~1.8' CLEARANCE FROM BLAST SHIELD
℄ ET TO RELOCATED G-23 AND G-24	6'-3"	6'-8 1/2"	8'-3 1/2"	6'-8 1/2"
℄ G-10 TO RELOCATED G-25 AND G-4 TO RELOCATED G-22	7'-7"	7'-1 1/2"	5'-6 1/2"	7'-1 1/2"
LOCATION OF NEW GIRDER TO SUPPORT RELEASE MECH FROM ℄ LRB	15'-7"	15'-7"	15'-7"	15'-7"
HAUNCH SIZE & SUPPORTS	TBD	TBD	TBD	TBD
ENGINE LAYOUT				

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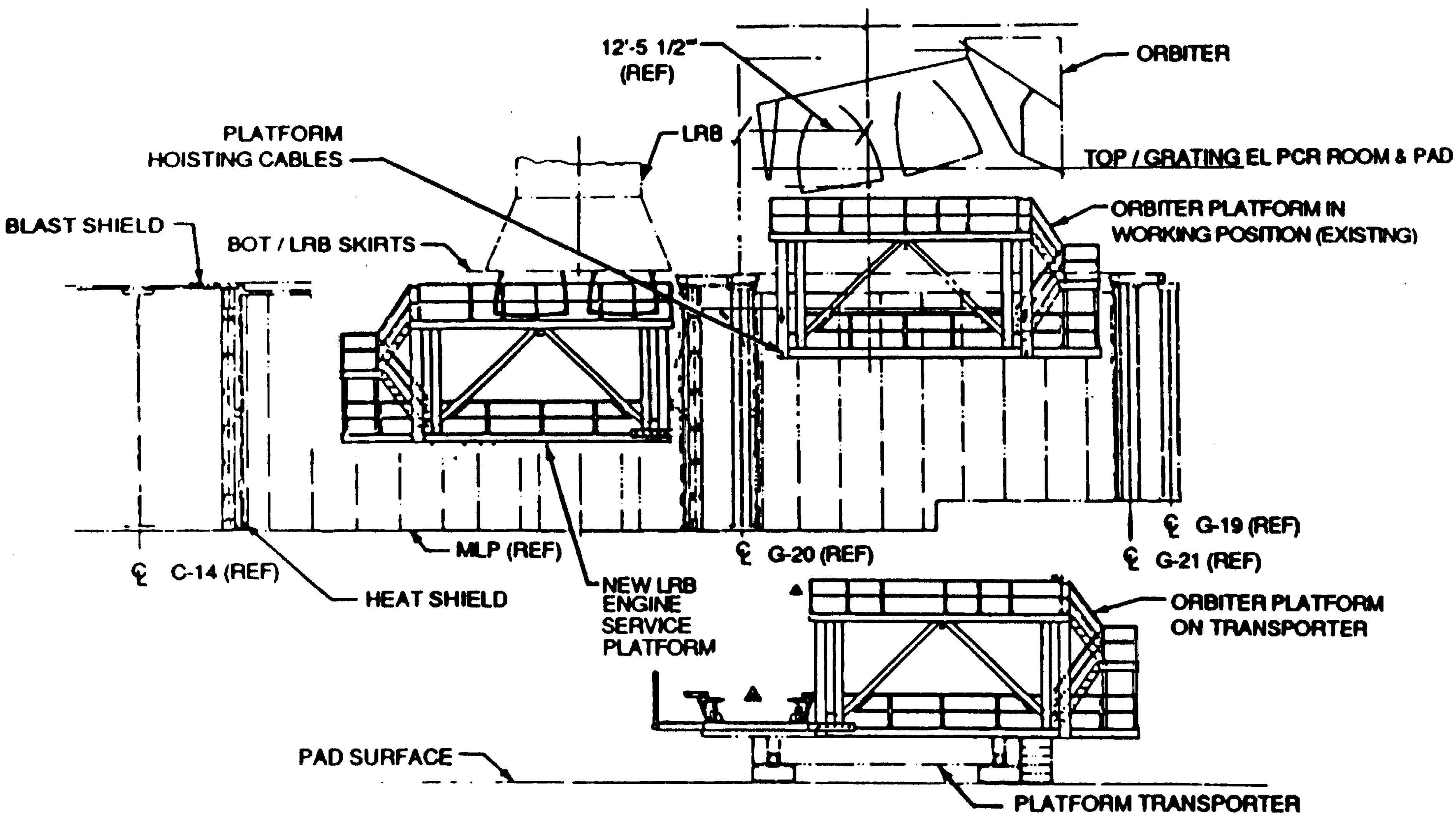
- NEW MLPs FOR LRB REQUIRED
  - EXTENSIVE DEMOLITION
  - FLAME IMPINGEMENT IMPACT
  - G-20 STRUCTURAL IMPACT
  - G-20 COLUMN LINE FLAME IMPINGEMENT IMPACT
  - FOR X PATTERN ENGINES CROSS MEMBER FOR HOLDDOWN SUPPORT
  - INFRINGEMENT OF BOOSTER EXHAUST WITH SSME EXHAUST

LRB ENGINE LEVEL ACCESS

ACCESS FOR ENGINE MAINTENANCE CAN BE PROVIDED BY BUILDING PLATFORMS SIMILAR TO THE SSME PLATFORMS. AT PRESENT THE SSME SERVICE PLATFORMS ARE LIFTED INTO THE ORBITER EXHAUST HOLE OF THE MLP UTILIZING WINCHES. SIMILAR SERVICE PLATFORMS ARE USED FOR SRBs.

ENGINE SERVICE PLATFORMS



FRAME TRENCH

THE ANALYSIS OF THE FLAME TRENCH IS BASED ON THE ASSUMPTION THAT MODIFICATIONS TO THE EXISTING FLAME TRENCH MUST BE AVOIDED.

THE FLAME TRENCH CAN BE DESCRIBED AS A CONCRETE/STEEL CONSTRUCTION CHANNEL THAT CONTAINS THE LAUNCH EXHAUST PLUMES AND PROTECTS THE PAD STRUCTURES FROM BLAST AND EXHAUST DAMAGE. IT PROVIDES SUFFICIENT HEIGHT BETWEEN THE ENGINE AND THE IMPINGEMENT SURFACE, WHICH REDUCES THE POSSIBILITY OF EXHAUST REBOUNDING BACK TOWARD THE ORBITER. THE MAIN FLAME DEFLECTOR HAS TWO SIDES: ONE FOR THE ORBITER MAIN ENGINES AND THE OTHER FOR THE BOOSTERS. BOTH DIRECT THE EXHAUST DOWN THE TRENCH, AWAY FROM THE VEHICLE.

THIS STUDY HAS ANALYZED THE IMPACTS ON MAIN AND SIDE DEFLECTORS. THE BASELINE LRBs FOR THE ANALYSIS WERE THE GDSS AND MMC PUMP-FED CONCEPTS USING LOX/RP-1.

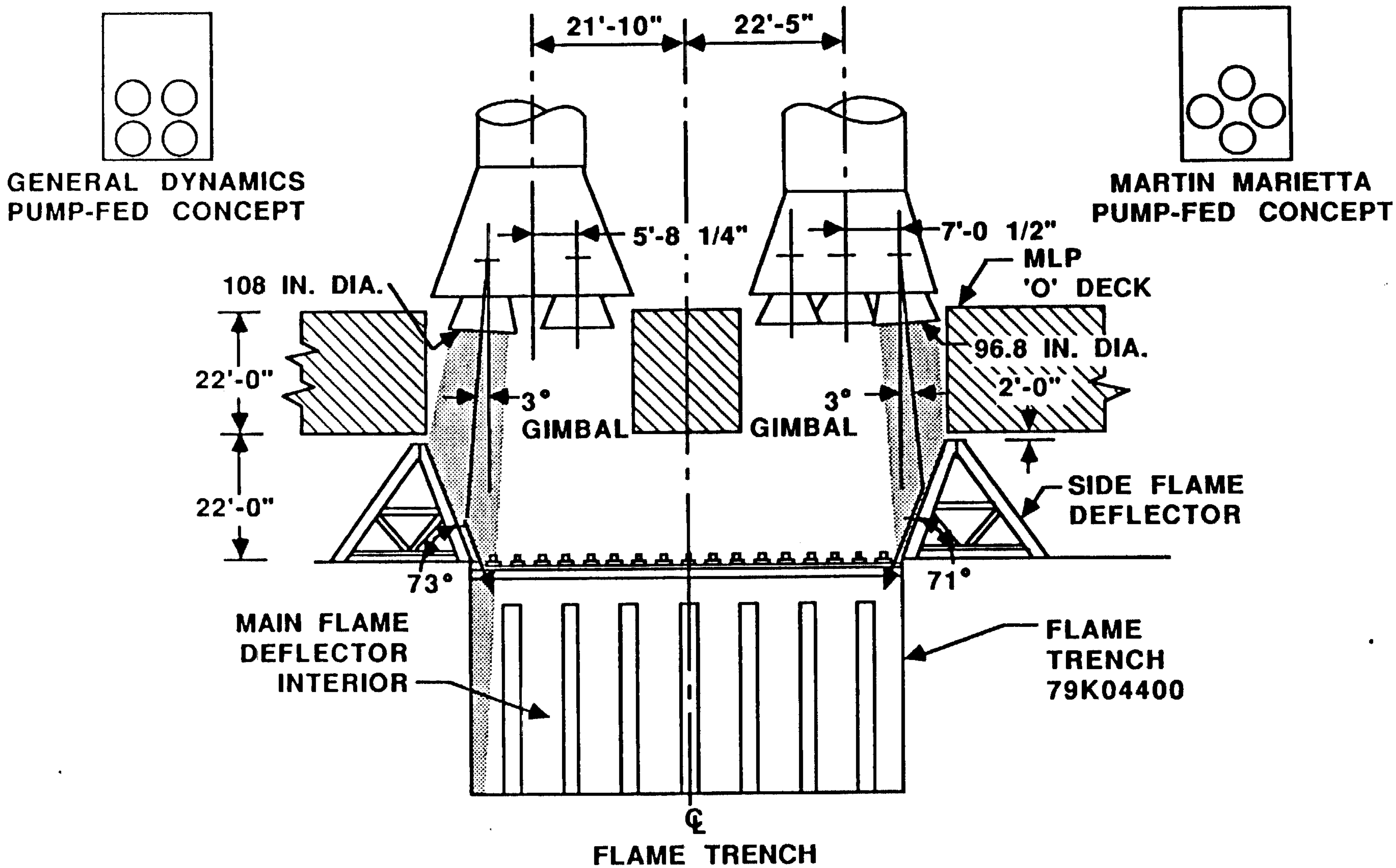
SIDE FLAME DEFLECTOR IMPACTS

THE PURPOSE OF THE SIDE FLAME DEFLECTORS IS TO DIRECT THE BLAST AND EXHAUST FLAMES TOWARD THE CENTER OF THE FLAME TRENCH AND TO PROTECT THE PAD STRUCTURES FROM DAMAGE. THERE ARE TWO SIDE FLAME DEFLECTORS LOCATED ON TOP OF THE PAD SURFACE AT THE EDGE OF THE FLAME TRENCH. THEY ARE MADE OF STRUCTURAL STEEL AND ROLLED INTO PLACE ON A RAIL. THEY ARE FASTENED DOWN PRIOR TO LAUNCH. THEY OCCUPY THE GAP BETWEEN THE BOTTOM OF THE MLP AND THE TOP OF THE PAD TO GIVE MAXIMUM PROTECTION.

MAIN FLAME DEFLECTOR IMPACTS

THE PURPOSE OF THE ORBITER SIDE OF THE MAIN FLAME DEFLECTOR IS TO DEFLECT THE BLAST PRESSURES FROM THE ORBITER ENGINES AWAY FROM THE SHUTTLE AND INTO THE FLAME TRENCH. IT ALSO DIRECTS THE WATER FLOW FROM THE SOUND SUPPRESSION DOWN TO THE TRENCH. THE DEFLECTOR IS A STRUCTURAL STEEL CONSTRUCTION, FIXED IN PLACE AND COVERED WITH REFRACTORY CONCRETE TO PROTECT THE STEEL. IT IS LOCATED IN THE BOTTOM OF THE FLAME TRENCH AND SLOPES UP TO THE EDGE OF THE FLAME TRENCH WALLS.

FLAME TRENCH DEFLECTORS (SOUTH ELEVATION)



SIDE FLAME DEFLECTORS

THERE ARE BASICALLY TWO LRB ENGINE CONFIGURATIONS; ONE BY GENERAL DYNAMICS SPACE SYSTEMS DIVISION AND ANOTHER BY MARTIN MARIETTA SPACE MANNED SYSTEMS. EACH HAS A FOUR-ENGINE CONFIGURATION WITH THE BASIC DIFFERENCE BETWEEN THEM BEING A CLOCKING ANGLE OF 90°

BOTH CONCEPTS OF THE LRB ENGINES HAVE THE CAPABILITY OF GIMBALLING 6° MAXIMUM FROM THE NEUTRAL POSITION. THIS INTRODUCES HIGHER BLAST PRESSURES ON THE SIDE DEFLECTORS AT MAXIMUM GIMBAL POSITION.

MAXIMUM IMPINGEMENT ANGLE OF THE FLAME DEFLECTORS IS DEPENDENT ON THE POSITION OF THE LRB ENGINES. THE BLAST PRESSURES INTRODUCED ON THE FLAME DEFLECTOR CAN BE EXTREME.

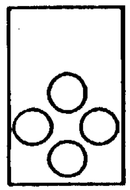
THE FIGURES SHOW BOTH GDSS AND MMC IMPACT CONCEPTS. ALL ENGINES ARE SHOWN IN THE G° GIMBALLED POSITIONS AND THE AREA OF IMPACT ON SIDE DEFLECTOR IS ILLUSTRATED. AT PRESENT SRB BLAST PRESSURE HAS NO DIRECT IMPINGEMENT ON SIDE FLAME DEFLECTORS. THE EXISTING SOUND SUPPRESSION SYSTEM ALSO RECEIVES DIRECT BLAST PRESSURES FROM LRB ENGINES. FURTHER EVALUATION AND STUDY ARE REQUIRED.

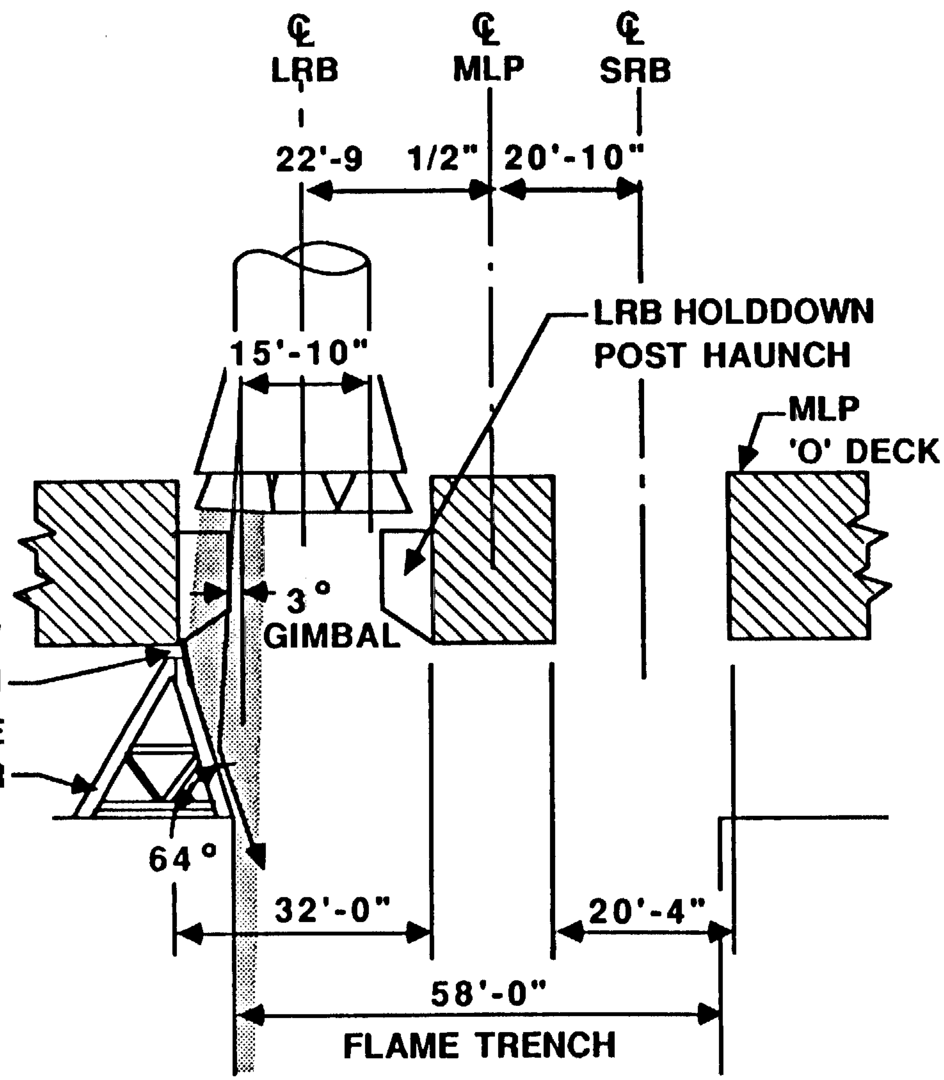
A NEW SEALING CONCEPT AND DESIGN WILL BE REQUIRED TO STOP EXHAUST FROM GOING BETWEEN THE MLP AND THE TOP EDGE OF THE SIDE DEFLECTORS.

SIGNIFICANT REDESIGN OF THE SIDE FLAME DEFLECTOR WILL BE REQUIRED. A 6.4 PER CENT SCALE MODEL TEST AND RECERTIFICATION FOR FLIGHT READINESS OF THE NEW DEFLECTORS IS REQUIRED.

SIDE DEFLECTOR FLAME IMPINGEMENT

MMC LOX/RP-1 PRESSURE-FED





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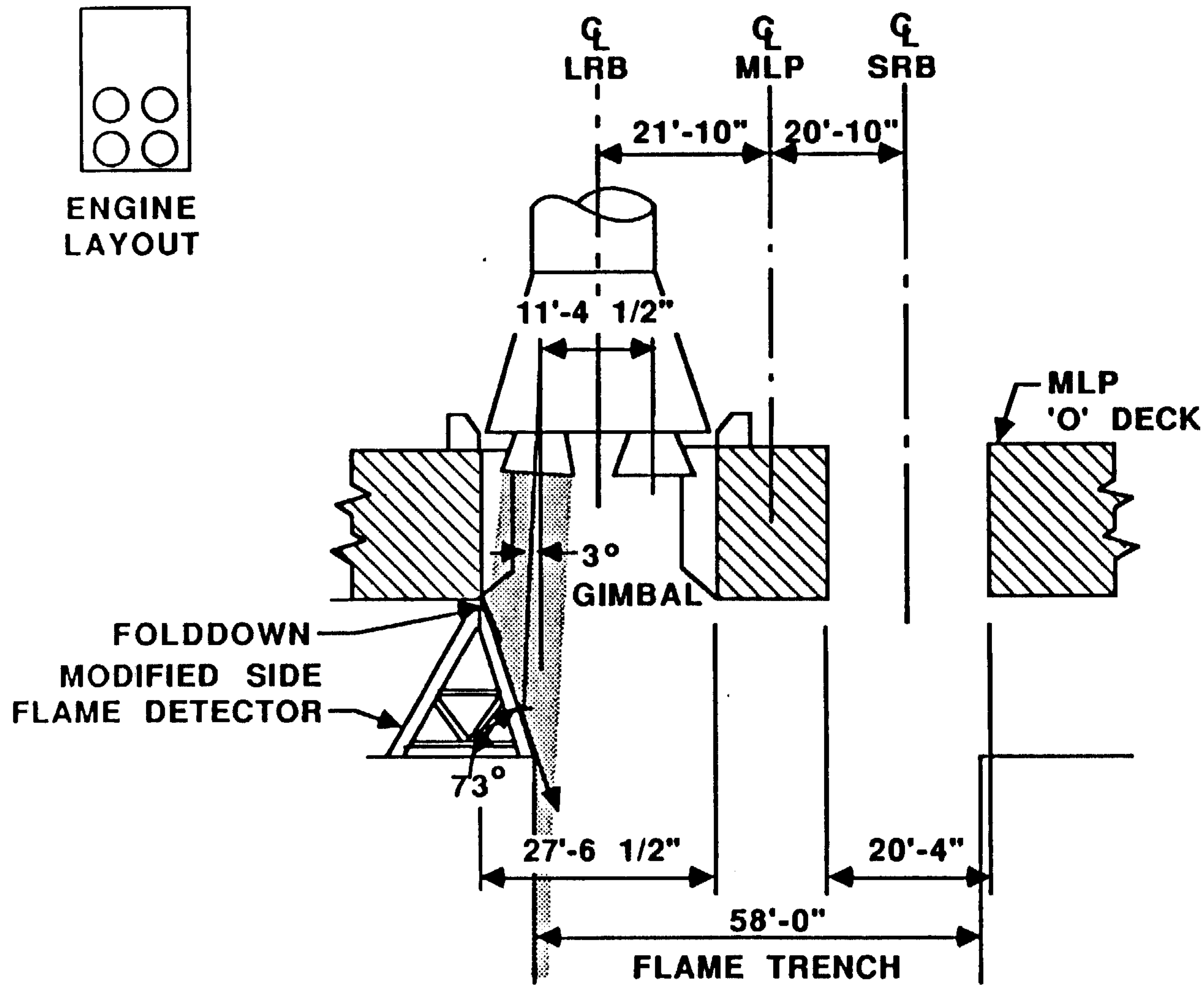
SIDE DEFLECTOR LAME IMPINGEMENT

MMC LOX/RP-1 PRESSURE-FED



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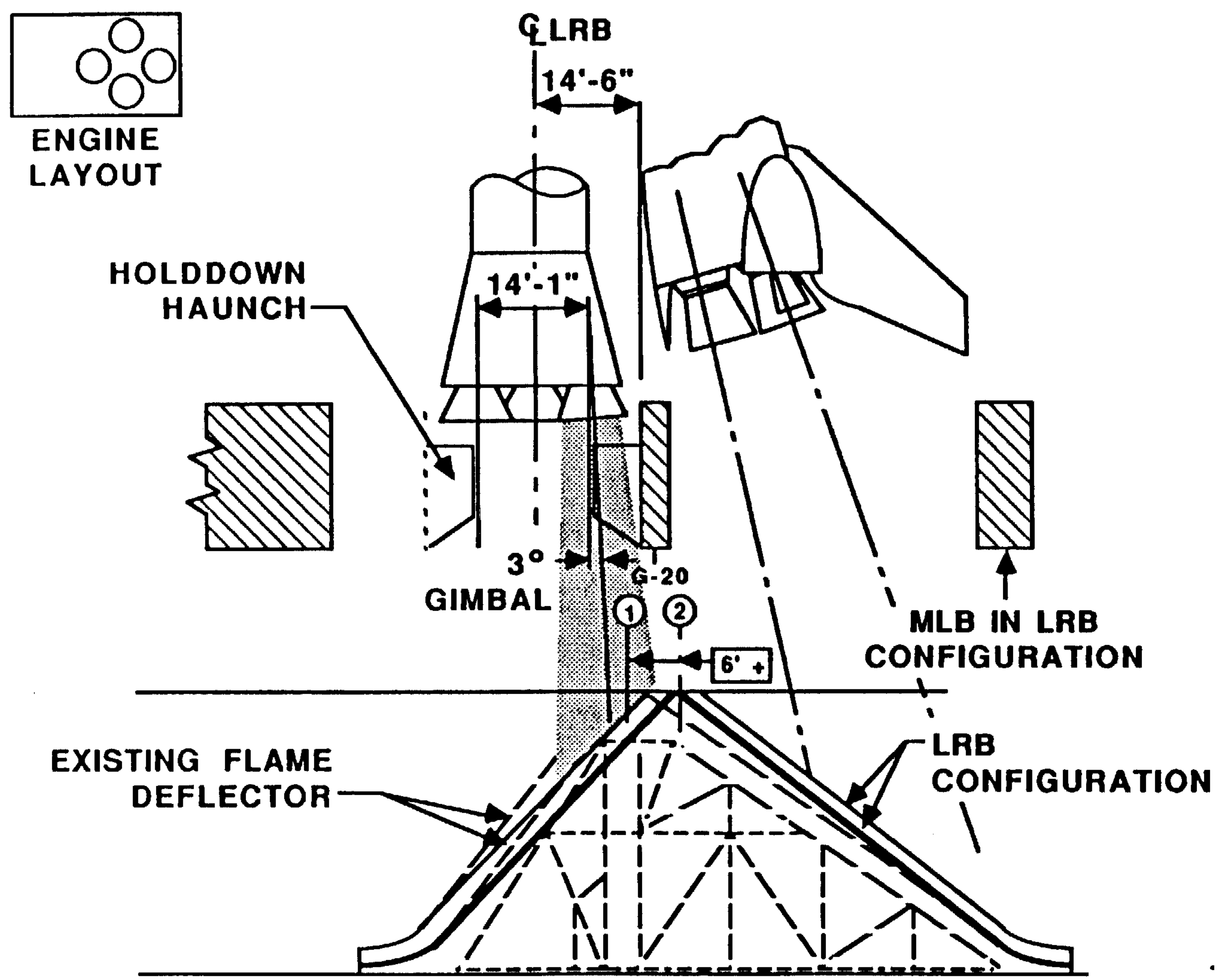
MAIN FLAME DEFLECTOR

AN EVALUATION OF THE EXISTING MAIN FLAME DEFLECTOR REVEALED MAJOR PROBLEMS. WITH THE CONFIGURATION OF THE NEW LRB ENGINES, THE BOOSTER BLAST PRESSURES HAVE SHIFTED SOUTH ON THE MAIN DEFLECTOR INTRODUCING A DIRECT HIT TO THE APEX OF THE DUAL ANGLE DEFLECTOR. THIS IS TRUE EVEN WITH THE LRB ENGINES IN THE NULL POSITION. THESE PRESSURES WILL INCREASE AS THE LRB ENGINES GIMBAL TO THEIR MAXIMUM POSITION AND SPILL-OVER INTO THE SSME SIDE IS LIKELY. THE MAIN DEFLECTOR NEEDS TO BE REDESIGNED AND POSITIONED SOUTH OF THE PRESENT LOCATION TO AVOID THIS CONDITION.

MAIN DEFLECTOR FLAME IMPINGEMENT

MMC LOX/RP-1 PUMP-FED



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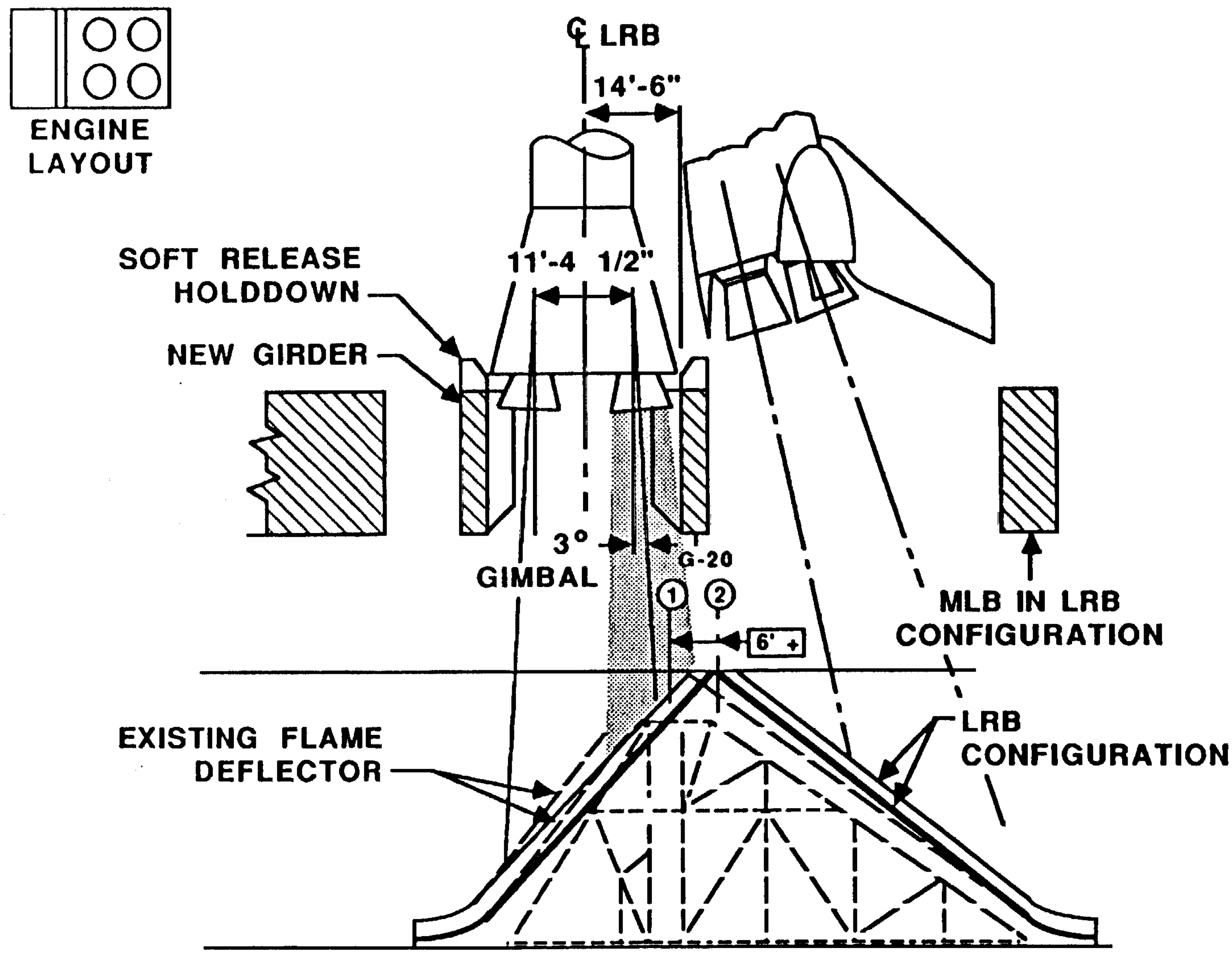
MAIN DEFLECTO.. FLAME IMPINGEMENT

MMC LOX/RP-1 PUMP-FED

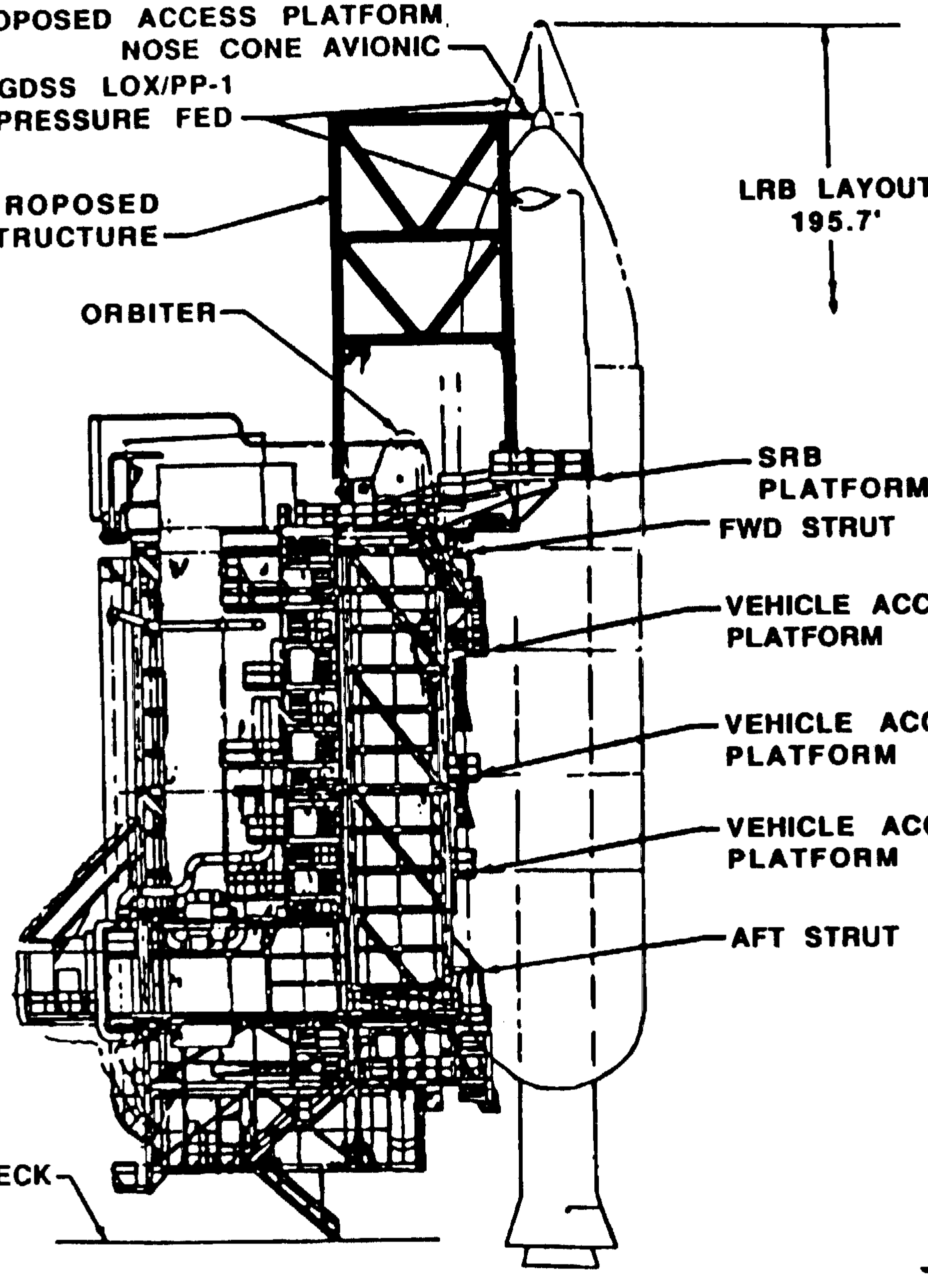


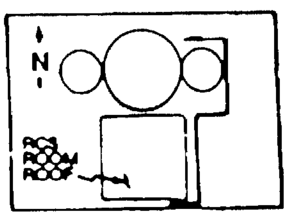
LRB ACCESS REQUIREMENTS

INTERTANK ACCESS. THE ACCESS REQUIREMENTS FOR THE MMC LOX/RP-1 PUMP-FED CONCEPT IS APPROXIMATELY 55 FT ABOVE THE "0" DECK LEVEL OF THE MLP. THIS ACCESS COULD BE ACHIEVED BY PROVIDING A MOVABLE PLATFORM FROM THE EXISTING ORBITER WEATHER PROTECTION. ADDITIONAL CATWALKS OR PLATFORMS WOULD BE REQUIRED TO GAIN ACCESS FROM THE FSS. A FURTHER STUDY IS REQUIRED FOR THE INTERTANK ACCESS REQUIREMENTS OF THE MMC LOX/RP-1 PRESSURE-FED AND THE LOX/RP-1 PUMP-FED AND GDSS CONCEPTS. THEIR LOCATIONS WOULD REQUIRE ADDITIONAL SUPPORT STRUCTURES. THE EXISTING ET/ORBITER ACCESS PLATFORMS CAN BE USED FOR INTERTANK ACCESS OF THE TALLER BOOSTERS IF THE HATCH IS LOCATED APPROPRIATELY.

FORWARD (NOSE CONE) AREA ACCESS - THIS AREA IS ABOUT THE SAME LEVEL AS FOR SRB FORWARD AREA ACCESS. WITH DOME MODIFICATIONS TO THE EXISTING PLATFORM, ACCESS TO THE FORWARD AREA FOR LRB CAN BE ACHIEVED. THIS IS GOOD FOR MMC LOX/RP-1 PUMP-FED AND GDSS CONCEPTS. BUT, FOR TALLER BOOSTERS THERE IS NO EXISTING STRUCTURES TO SUPPORT ACCESS. A FURTHER STUDY WILL BE REQUIRED. THIS STUDY WILL EXAMINE THE POSSIBILITY OF ADDING STRUCTURAL MEMBERS FROM FSS/RSS STRUCTURES TO SOLVE THESE ACCESS PROBLEMS. A PROPOSED CONCEPT IS SHOWN. THIS CONCEPT REQUIRES IN-DEPTH ANALYSIS AND DESIGN.

ACCESS PLATFORMS





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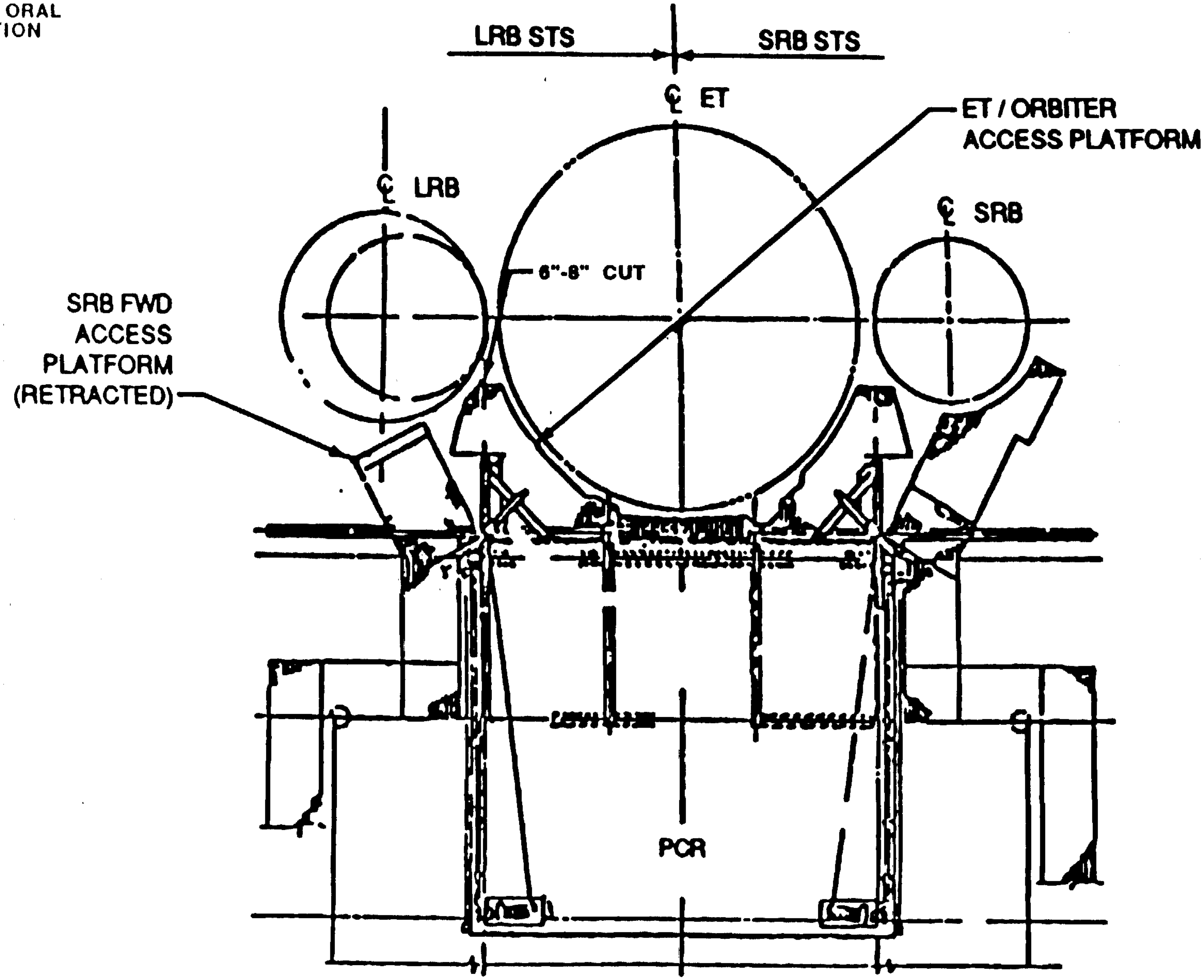
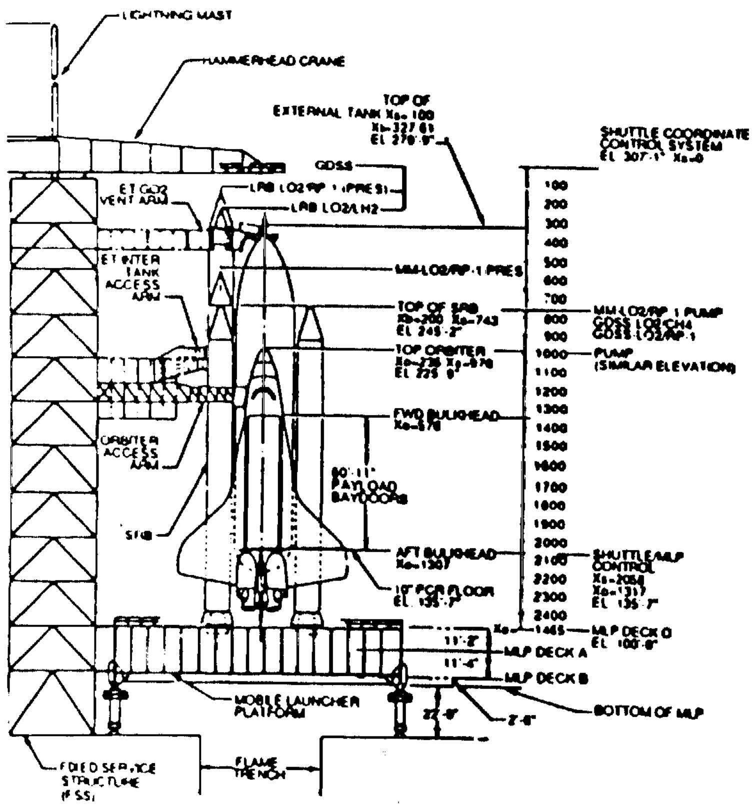
LAUNCH PAD ACCESS PLATFORMS





ORBITER/ET UMBILICAL IMPACTS

THIS SECTION DESCRIBES THE IMPACT TO EXISTING LC-39 UMBILICALS AND SWING ARMS THAT WILL RESULT FROM A CONVERSION FROM SRBs TO LRBs IN THE SPACE SHUTTLE PROGRAM.

FIVE MAJOR UMBILICALS AND THREE SWING ARMS ARE REQUIRED TO SERVICE THE SRB-CONFIGURED SHUTTLE SYSTEM AT THE LAUNCH PAD. OF THESE, ALL BUT THE SRB JOINT HEATER UMBILICALS WILL STILL BE REQUIRED FOR AN LRB-EQUIPPED SHUTTLE.

EXISTING ORBITER AND ET GROUND INTERFACES WILL REMAIN AT CURRENT POSITION RELATIVE TO LC-39. NUMBER AND SIZE OF CONNECTIONS ACROSS EXISTING ORBITER AND ET GROUND INTERFACES WILL NOT CHANGE SIGNIFICANTLY. ALTHOUGH IT IS ASSUMED FOR THE PURPOSE OF THIS STUDY THAT THE VEHICLE EXCURSIONS WILL NOT CHANGE, THE IMPACT OF AN INCREASE SHOULD BE CONSIDERED. A SIGNIFICANT INCREASE IN VEHICLE EXCURSIONS COULD AFFECT ALL THE EXISTING SYSTEMS REQUIRING HARDWARE MODIFICATIONS AND REQUIRE LETF TESTING. TWO SYSTEMS IN PARTICULAR, THE GOX VENT AND TSM's, CURRENTLY HAVE VERY LITTLE CAPABILITY FOR EXCURSION GROWTH WITHOUT HARDWARE MODIFICATION. ALSO, THE ET GH2 VENT AND OAA HAVE LIMITED CAPABILITY FOR EXCURSION INCREASES. ALTHOUGH VEHICLE LAUNCH DRIFTS WILL CHANGE DUE TO A DECREASE IN THE THRUST-TO-WEIGHT RATIO AND BLAST LOADS WILL CHANGE THEY STILL NEED TO BE ADDRESSED IN GREATER DETAIL IN PHASE B.

BASED ON THE ASSUMPTIONS OF THIS STUDY, THE PRIMARY CONCERN FOR LRB COMPATIBILITY IS THAT LRBs HAVE SUFFICIENT CLEARANCE FOR ALL PRELAUNCH CONDITIONS. GROUND SYSTEMS MUST CLEAR LRB's DURING DISCONNECT AND RETRACTION. THE LRB's MUST CLEAR SYSTEMS FOR WORST CASE LAUNCH DRIFTS.

ORBITER LSE LETF TEST REQUIREMENTS

CANDIDATE LSE	LSE MOD / RETEST
ORBITER ACCESS ARM (1 EACH PAD)	MOD / RETEST DEPENDENT ON EXCURSIONS OF LRB / SSV
ET INTERTANK ACCESS ARM (1 EACH PAD)	MOD / RETEST DEPENDENT ON EXCURSIONS OF LRB / SSV
MOD OF ET GH2 VENT LINE / ARM SYS (1 EACH PAD)	MOD / RETEST DUE TO LRB DIAMETER
MOD OF ET GOX VENT ARM AND SYS (1 EACH PAD)	MOD / RETEST DUE TO LRB LENGTH
MOD OF LOX / LH2 TSM (2 EACH MLP)	MOD / RETEST DEPENDENT ON EXCURSIONS OF LRB / SSV

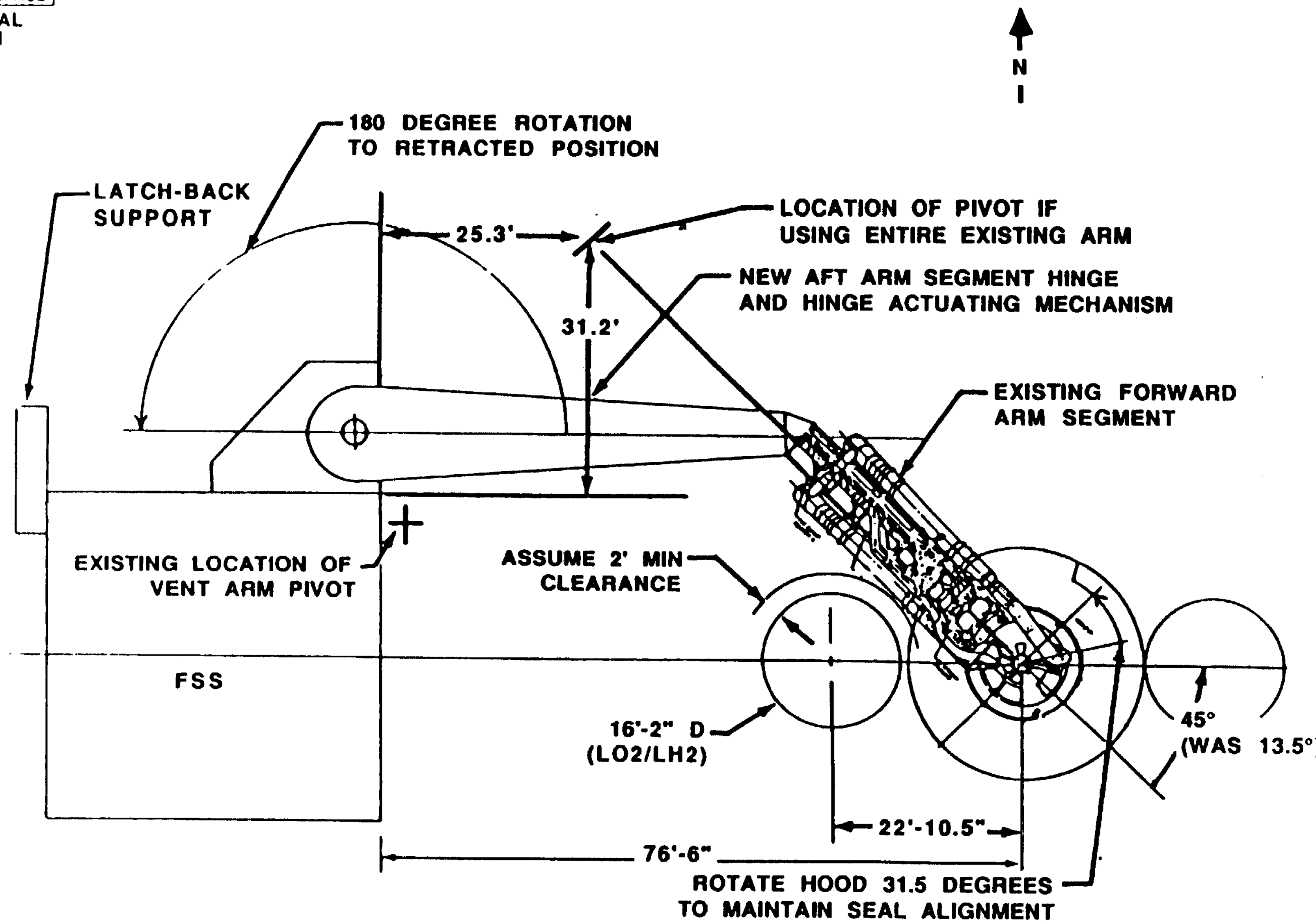
GOX VENT ARM

THIS ARM WILL BE GENERALLY UNAFFECTED BY THE DIAMETER FOR ANY OF THE LRB CONCEPTS. HOWEVER, LRB LENGTHS OVER 170 FT WILL HAVE HARD INTERFERENCE WITH THE EXISTING STRUCTURE.

TO ACCOMMODATE THE ET GOX VENTING FOR THE LONGER LRBs, IT WILL BE NECESSARY TO PLACE THE VENT ARM ALONGSIDE THE BOOSTER RATHER THAN OVER IT, AS IN THE EXISTING DESIGN. FOR A GDSS-LO2/LH2 LRB TO OBTAIN A 2-FT CLEARANCE, IT WOULD BE NECESSARY TO PLACE THE VENT ARM AT 45 DEGREES TO THE BOOSTER CENTERLINE. THE ARM COULD BE PROJECTED NORTH OR SOUTH OF THE VEHICLE. NORTH WAS CHOSEN TO PLACE THE PIVOT CLOSER TO THE EXISTING POSITION, THEREBY SIMPLIFYING ROUTING OF FLUID AND ELECTRICAL SERVICE LINES.

THE CONCEPT WILL USE AS MUCH OF THE EXISTING ARM AND ASSOCIATED COMPONENTS AS POSSIBLE, BUT IT WOULD REQUIRE A NEW OR MODIFIED HOOD ASSEMBLY, A NEW AFT ARM SEGMENT, NEW HINGE AND HINGE ACTUATING MECHANISM, AND STRUCTURAL ADDITIONS TO THE FSS. ADDITIONALLY, A MODIFICATION OF THIS MAGNITUDE WOULD ALMOST CERTAINLY REQUIRE LAUNCH EQUIPMENT TEST FACILITY (LETF) REQUALIFICATION.

GOX VENT ARM MOD



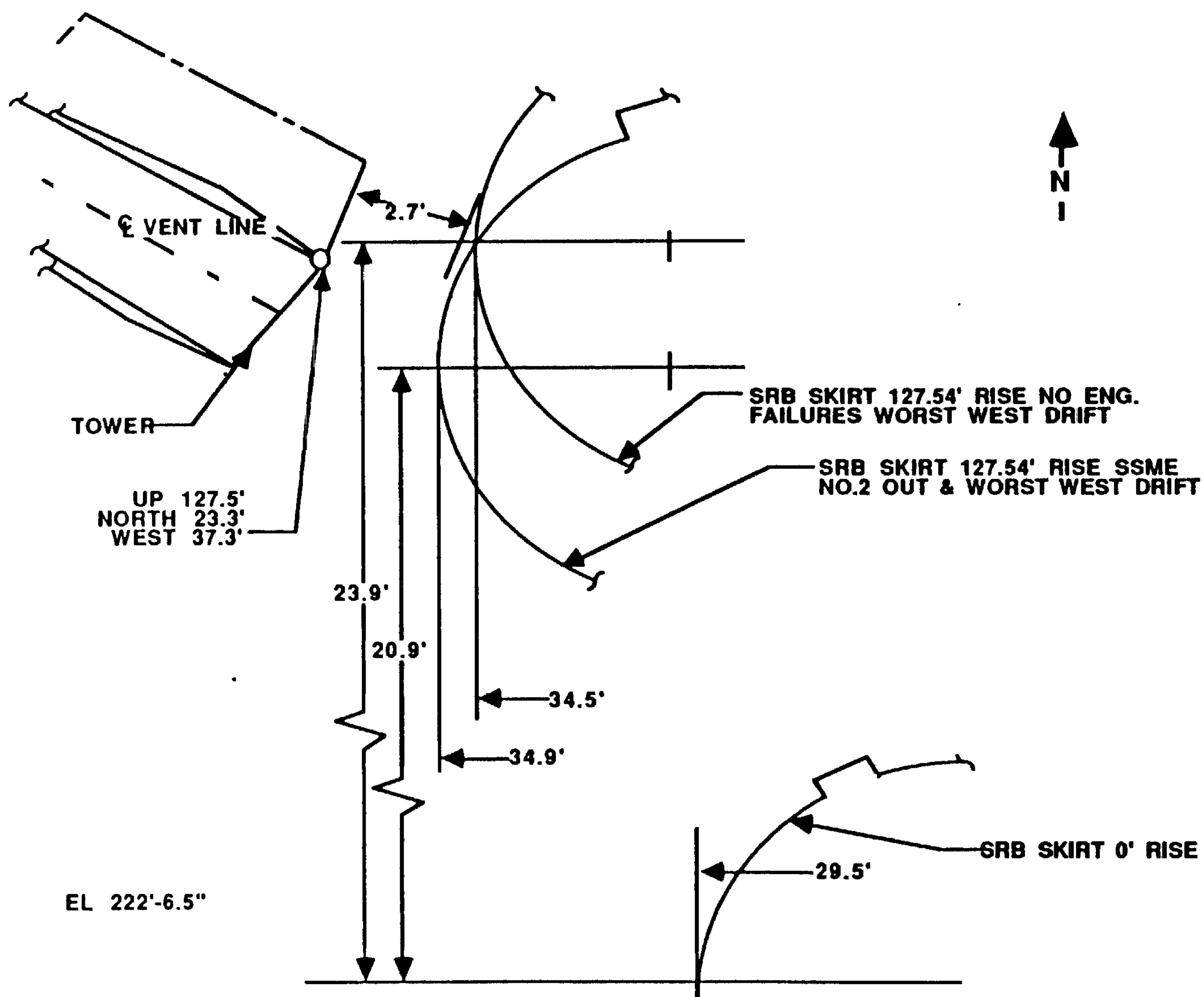
ET H2 VENT

THERE ARE TWO MAJOR AREAS OF CONCERN FOR LRB COMPATIBILITY WITH THIS UMBILICAL. THE FIRST AND MOST SIGNIFICANT CONCERN DEALS WITH VEHICLE DRIFT CLEARANCE TO THE ET VENT SUPPORT STRUCTURE. THE MINIMUM CLEARANCE OCCURS AS THE SKIRT PASSES THE 222-FT 6.5-IN LEVEL. A PLAN VIEW IS SHOWN OF THE SRB SKIRT TO STRUCTURE CLEARANCE AT THE 222-FT 6.5-IN LEVEL. NOTE THE MINIMUM CLEARANCE IS 2.7 ft.

ASSUMING A SIMILAR DRIFT FOR THE LRB's Vs SRB AND APPLYING THE LARGER SKIRT DIAMETERS, THE STRUCTURE-TO-VEHICLE RELATIONSHIP IS SHOWN. NOTE THAT ALL THE LRB CONCEPTS SHOW INTERFERENCE AT THE 222-FT 6.5-IN LEVEL. UNLESS THE DRIFTS COULD BE MODIFIED TO OBTAIN CLEARANCE, IT WILL BE NECESSARY TO RELOCATE THE ET VENT STRUCTURE. BUT RELOCATING THE STRUCTURE WOULD OBVIOUSLY PRODUCE SOME MAJOR SYSTEM IMPACTS. FIRST, SINCE THE ET INTERTANK ACCESS ARM IS MOUNTED ON THE STRUCTURE, IT WOULD HAVE TO BE LENGTHENED TO REACH THE ET. ALSO, THE DISTANCE THE STRUCTURE IS MOVED WOULD REQUIRE ADDITIONAL UMBILICAL VENT LINES. AND LENGTHENING THE VENT LINE WOULD NECESSITATE MODIFYING THE LOWER LEVEL OF THE ET VENT STRUCTURE AND DECELERATION UNIT, SINCE THE VENT LINE WOULD EXTEND TO A LOWER LEVEL IN THE RETRACTED POSITION. (VENT LINE IS VERTICAL WHEN RETRACTED.) FURTHERMORE, LENGTHENING THE VENT LINE WOULD AGGRAVATE THE ALREADY MARGINAL SAFETY FACTOR FOR THE PYRO-BOLT, WHICH HOLDS THE UMBILICAL TO THE VEHICLE. MAINTAINING THE PYRO-BOLT LOAD WITHIN ACCEPTABLE LIMITS COULD PROVE VERY DIFFICULT AND COULD LEAD TO REVISION OF THE BASIC OPERATING DESIGN OF THE UMBILICAL.

IN SUMMARY, IF RELOCATING THE ET VENT STRUCTURE IS NECESSARY, AN EXTENSIVE DESIGN AND MODIFICATION EFFORT WOULD BE REQUIRED, ALONG WITH LETF REQUALIFICATION TESTING.

SRB SKIRT ET H2 VENT CLEARANCE



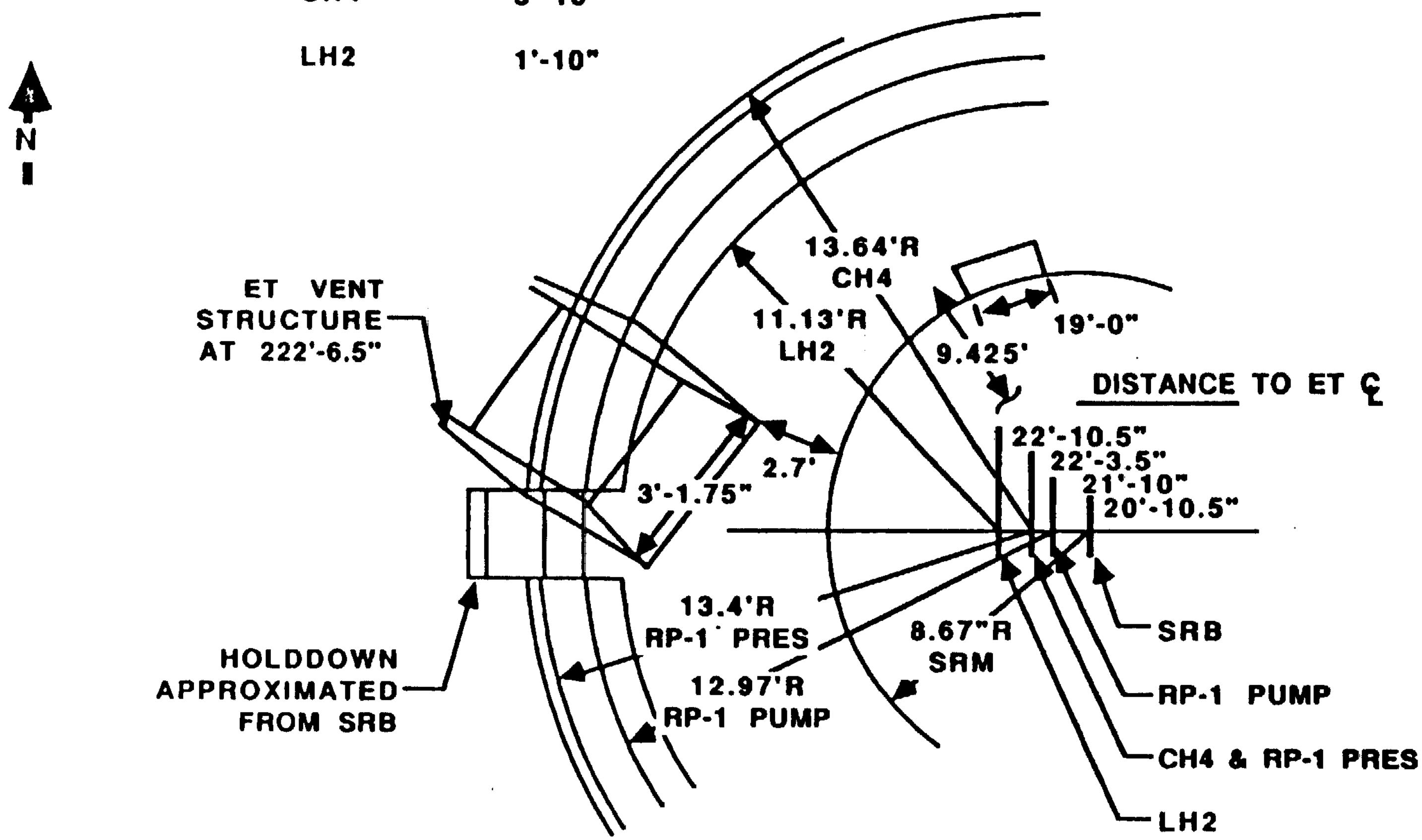
ET H2 VENT

THE SECOND AREA OF CONCERN FOR THE ET VENT DEALS WITH CLEARANCE OF THE LRB DURING UMBILICAL DISCONNECT AND RETRACT. THE FIGURE SHOWS THE RESULTING CLEARANCE (OR INTERFERENCE) AFTER SUBSTITUTING THE LARGER LRB DIAMETERS. AS SHOWN, ONLY THE GDSS RP-1 PUMP-FED HAS ANY CLEARANCE REMAINING. ASSUMING A CLEARANCE OF 12 INCHES IS DESIRED FOR ALL CASES, SOME MODIFICATION WOULD HAVE TO BE MADE TO THE UMBILICAL.

A CONCEPT WHICH COULD ALLEVIATE THIS PROBLEM INVOLVES USING A CAM ARRANGEMENT ON THE VENT LINE PIVOT, WHICH WOULD SWING THE UMBILICAL AROUND THE LRB DURING RETRACT. THIS CONCEPT COULD CONCEIVABLY BE IMPLEMENTED WITHOUT MAJOR MODIFICATIONS TO THE SYSTEM. HOWEVER, SOME LETF TESTING WOULD BE REQUIRED.

ET GH2 VENT

LRB	INTERFERENCE
RP-1 PUMP	2'-9"
RP-1 PRES	3'-7"
CH4	3'-10"
LH2	1'-10"



USING WORST WEST DRIFT FOR SRB (SSME NO 2 OUT)

* MM RP-1 PUMP AND PRESS HAVE SIMILAR INTERFERENCES

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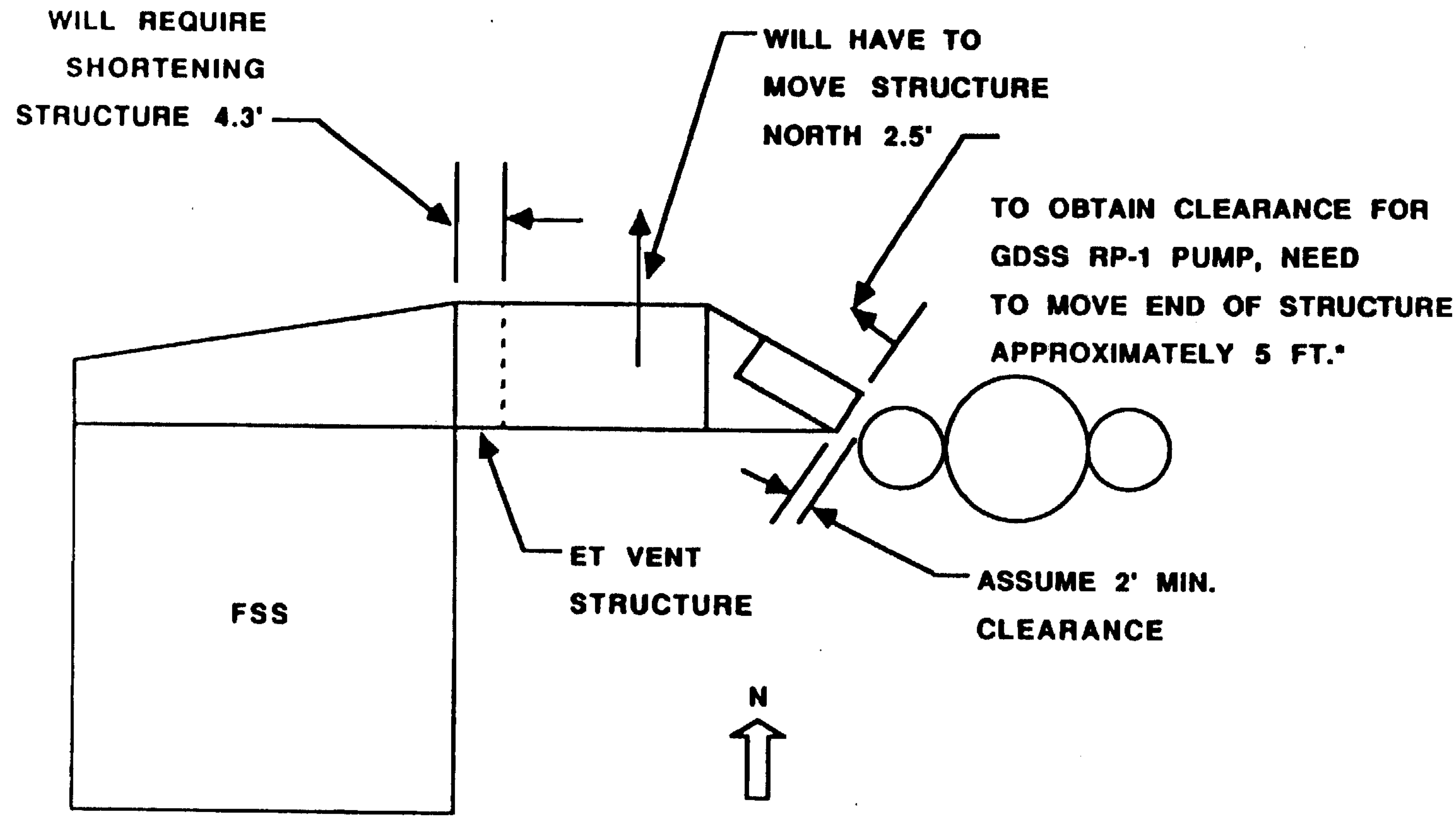
ET H2 VENT ARM MOD LOCATION

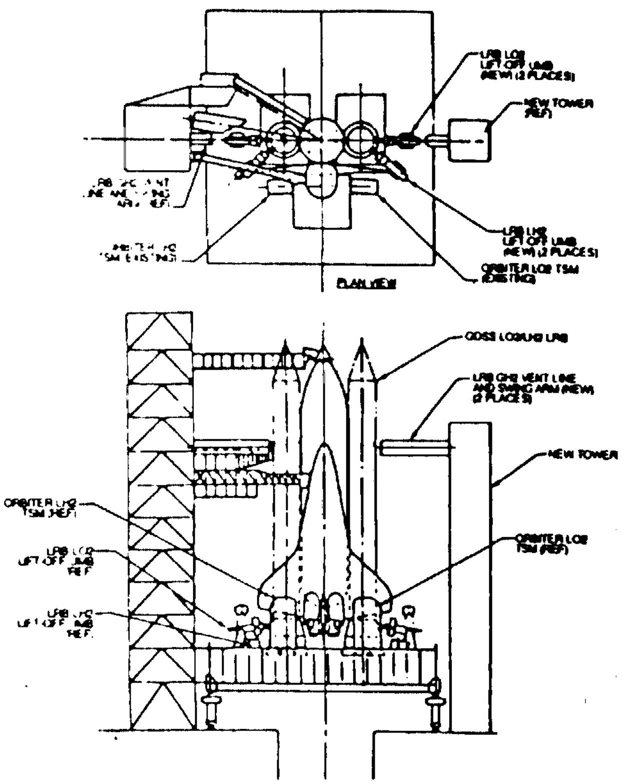


* ALL THE LRB CONCEPTS REQUIRE RELOCATION OF ET VENT STRUCTURE (ASSUMING SRB DRIFTS).

-WORST CASE GDSS LO2/CH4 = 6 FT. RELOCATION

-BEST CASE GDSS LO2/LH2 = 4 FT. RELOCATION

LRB UMBILICALS



LRB Umbilicals, GDSS LO2/LH2 Concept

NEW CRYOGENIC UMBILICAL REQUIREMENTS

EACH OF THE LRB CONCEPTS WOULD REQUIRE, AT THE LEAST, AN LO2 FILL AND DRAIN UMBILICAL. THE GDSS LO2/LH2 LRB CONCEPT WOULD ALSO REQUIRE LH2 FILL/DRAIN AND VENT UMBILICALS FOR EACH LRB. LIKEWISE, THE GDSS LO2/LCH4 LRB CONCEPT WOULD REQUIRE LCH4 FILL/DRAIN AND VENT UMBILICALS FOR EACH LRB IN ADDITION TO THE LO2 UMBILICALS. ALL THE NEW UMBILICAL GSE SYSTEMS WOULD REQUIRE COMPLETE LETF VALIDATION AND QUALIFICATION TESTING.

CRYOGENIC VENT UMBILICAL REQUIREMENTS

ALTHOUGH AN ASSUMPTION WAS MADE THAT VENT INTERFACES FOR THE CRYOGENIC PROPELLANTS WOULD BE PROVIDED IN THE SKIRT AREA AND LOX WOULD VENT TO ATMOSPHERE, THERE IS THE POSSIBILITY THAT UMBILICALS MIGHT BE LOCATED AT UPPER ELEVATIONS.

IT WILL BE REQUIRED TO CAPTURE H2 AND CH4 BECAUSE OF THEIR HAZARDOUS NATURE. THE LRB CONFIGURATION USING LH2 AND LCH4 MAY HAVE UMBILICALS WHICH WOULD REQUIRE SWING ARMS AND TOWERS.

CONCLUSIONS/RECOMMENDATIONS

THE REQUIREMENT FOR NEW VENT UMBILICAL AND SWING ARM SYSTEMS, ASSOCIATED FSS MODIFICATIONS, AND A NEW SUPPORT TOWER STRUCTURE CAN BE ELIMINATED BY REQUIRING THE GDSS LO2/LH2 AND LO2/LCH4 LRB CONCEPTS TO HAVE AFT SKIRT VENT UMBILICALS.

LRB LSE LETF TEST REQUIREMENTS

CANDIDATE LSE / LRB OPTION	MM LO2 / RP-1 PUMP	MM LO2 / RP-1 PRESSURE	GDSS LO2 / RP-1 PUMP	GDSS LO2 / RP-1 PRESSURE	GDSS LO2 / LH2	GDSS LO2 / CH4
NEW LO2 UMB FOR EACH LRB (2 EACH MLP)	X	X	X	X	X	X
NEW LH2 UMB FOR EACH LRB (2 EACH MLP)					X	
NEW CH4 UMB FOR EACH LRB (2 EACH MLP)						X
NEW GH2 VENT LINE & SWING ARM FOR EACH LRB (2 EACH PAD IF REQD)					X	
NEW CH4 VENT LINE & SWING ARM FOR EACH LRB (2 EACH PAD IF REQD)						X
NEW HOLDDOWN SYSTEM (8 EACH MLP)	X	X	X	X	X	X
NEW POWER / INST. FOR EACH LRB (2 EACH MLP)	X	X	X	X	X	X
NEW RP-1 UMB & SERVICE MAST FOR EACH LRB (2 EACH PAD)	X	X	X	X		

ORBITER WEATHER PROTECTION SYSTEM

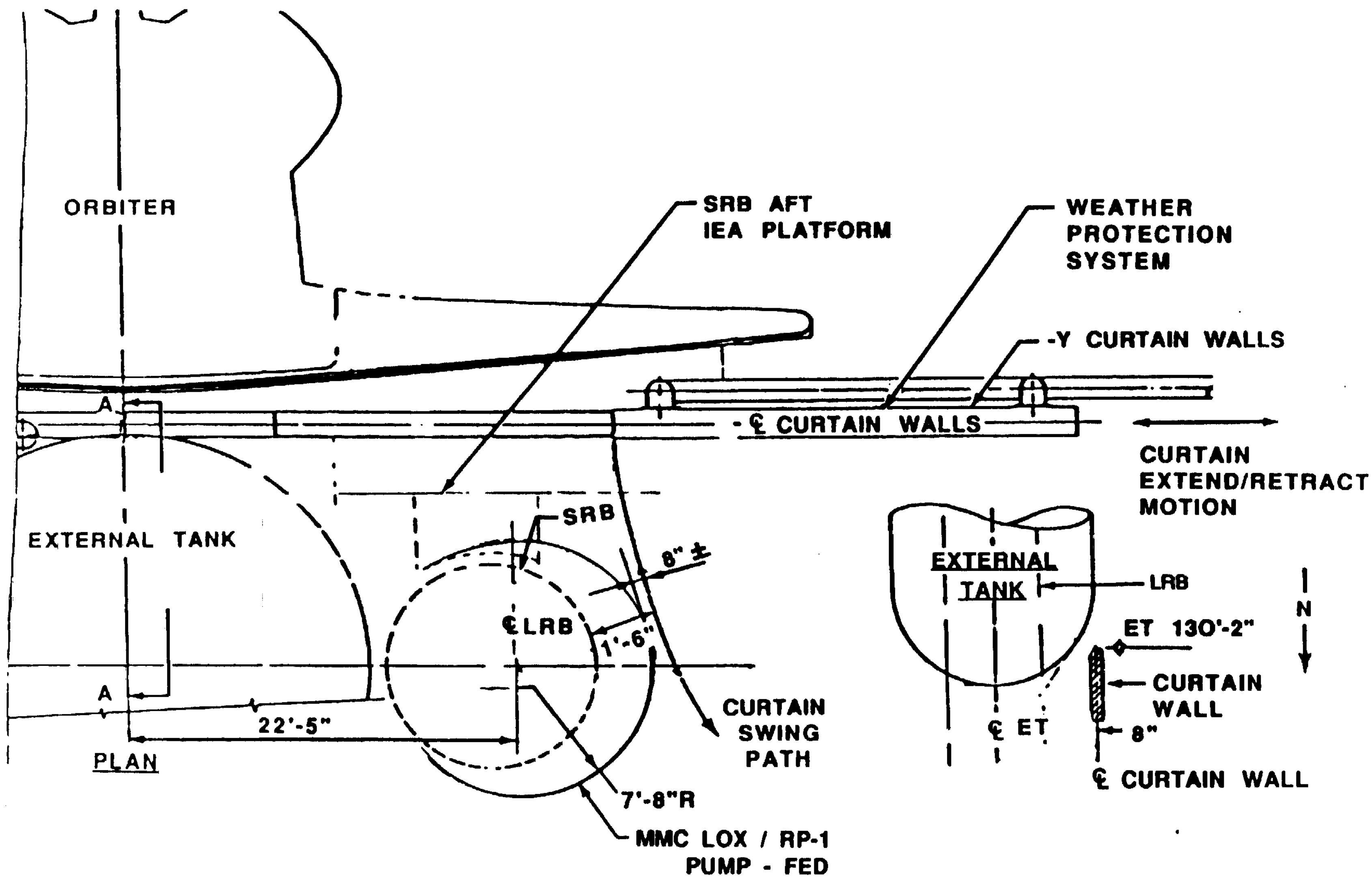
THIS SECTION WILL IDENTIFY THE IMPACTS TO SWING PATH OF THE -Y CURTAIN WALL BY THE LRB CONCEPTS.

A DYNAMIC CLEARANCE OF 1 FOOT SIX INCHES MUST BE MAINTAINED FROM FLIGHT HARDWARE TO HARD STEEL.

THE MMC LOX/RP-1 PUMP-FED LRB CONCEPT IN THE FIGURE SHOWS A CLEARANCE OF 8 INCHES FROM THE -Y CURTAIN WALL DURING THE EXTEND/RETRACT OPERATION. ALL OTHER LRB CONCEPTS WITH LARGER DIAMETERS WILL HAVE A GREATER IMPACT.

THIS DIRECT IMPACT ON THE EXISTING ORBITER WEATHER PROTECTION SYSTEM CANNOT BE ADDRESSED THOROUGHLY IN THIS STUDY. THE MODIFICATIONS REQUIRED WOULD BE DETERMINED BY STRUCTURAL ANALYSIS AND FURTHER DESIGN STUDY UPON COMPLETION OF LRB DOWN SELECTION.

WEATHER PROTECTION SYSTEM CLEARANCE IMPACTS



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PRESSURE-FED LRB PRESSURIZATION GSE

THE LRB PRESSURE-FED SYSTEM WILL BE EQUIPPED WITH ONBOARD PRESSURANT BOTTLES THAT WILL BE PRESSURIZED TO APPROXIMATELY 3,000 psig.

THERE ARE TWO PRESSURANT CANDIDATES BEING PROPOSED FOR LRB USE:

THE GENERAL DYNAMICS CONFIGURATIONS USE TRIDYNE (He, H_2, O_2.) TRIDYNE WOULD BE SUPPLIED IN TUBEBANK TRAILERS BY GENERAL DYNAMICS. THE TRAILER WILL BE PARKED INSIDE THE PAD HIGH PRESSURE GAS STORAGE FACILITY. SUPPLY GAS FROM THE TUBEBANK IS CONVEYED TO A PRESSURANT REGULATION PANEL WHERE IT WILL BE REGULATED, MONITORED, AND DELIVERED TO THE LRB's.

THE MARTIN MARIETTA CONFIGURATIONS USE HELIUM 6,000 psig; GHe WOULD BE SUPPLIED TO THE PRESSURANT CONTROL PANEL FROM THE EXISTING PAD HIGH PRESSURE GAS STORAGE FACILITY. THE GHe LINE ALREADY EXISTS IN THE MLP AND WILL BE TAPPED AND ROUTED INTO THE LRB PRESSURANT CONTROL PANEL WHERE IT WILL BE REGULATED, MONITORED, AND DELIVERED TO THE TWO LRBs.

IF THE LRB BOTTLE FILL INTERFACE IS LOCATED ON THE LRB FORWARD SEGMENT, THE PRESSURE REGULATION WILL BE DONE WITH THE PANEL MOUNTED ON THE PCR ROOFTOP.

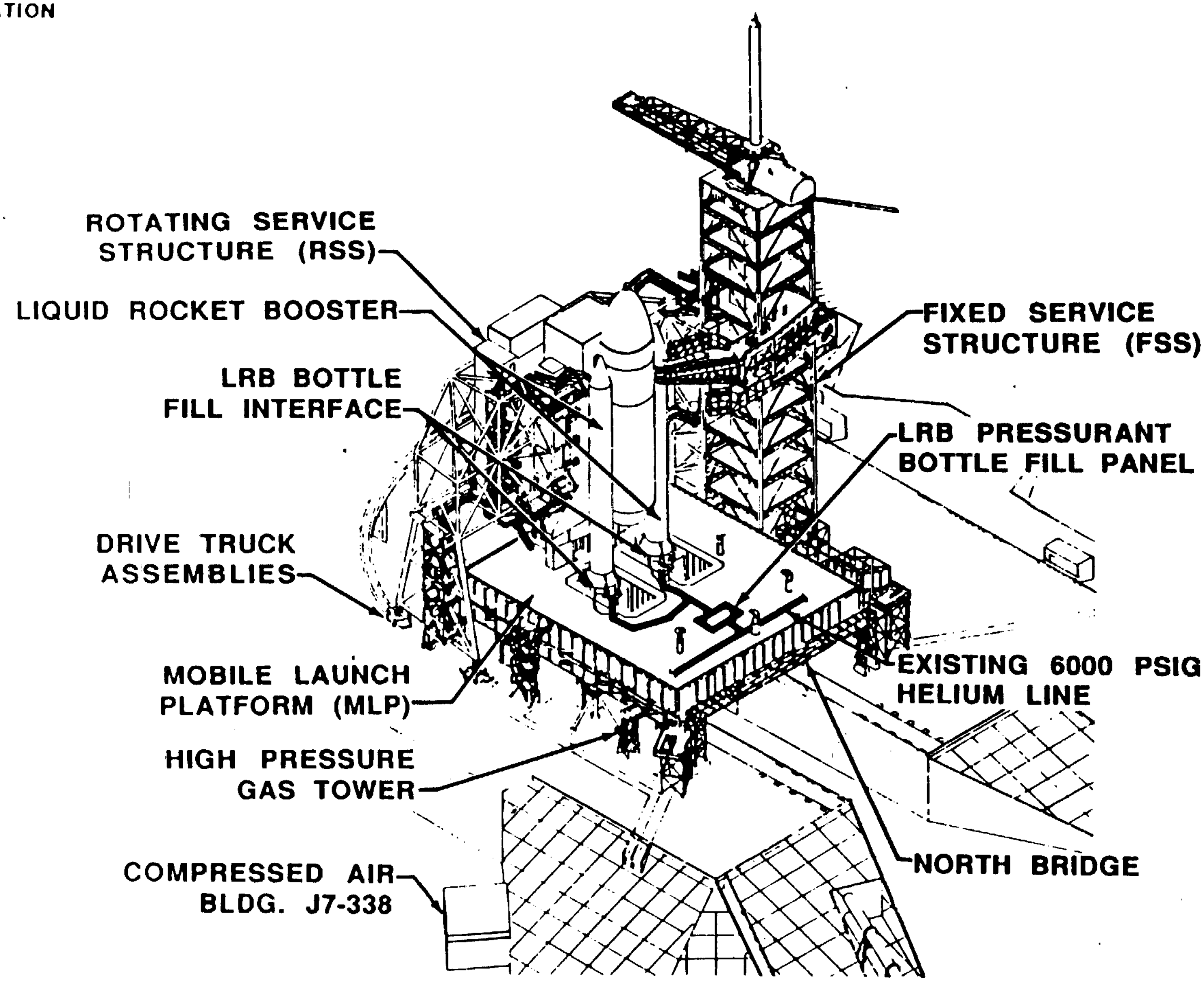
IF HELIUM IS USED FOR THE LRB PRESSURIZATION SYSTEM, THE HELIUM HIGH PRESSURE STORAGE BATTERY SHOULD BE EXPANDED. ADDITION OF 10 HIGH PRESSURE STORAGE BOTTLES WITH A CAPACITY OF 200 CUBIC FEET IS RECOMMENDED.

IF TRIDYNE IS USED FOR THE LRB PRESSURIZATION SYSTEM, A MINIMUM OF 11 TUBEBANK TRAILERS (ASSUMING EACH TUBEBANK TRAILER CAPACITY OF 200 CUBIC FEET) ARE REQUIRED.

HELIUM SHOULD BE USED WITH THE LRB PRESSURE-FED SYSTEM. IT IS AN EXISTING AND KNOWN COMMODITY, AND DISTRIBUTION LINES ARE ALREADY IN PLACE.

THE ONBOARD PRESSURANT BOTTLE FILL INTERFACE SHOULD BE LOCATED ON THE AFT SEGMENT OF THE LRB FOR CONVENIENCE AND LESS INTERFERENCE WITH OTHER SHUTTLE SYSTEMS.

HELIUM PRESSURANT SYSTEM AFT FILL



PROPELLANT ACQUISITION, STORAGE, AND HANDLING

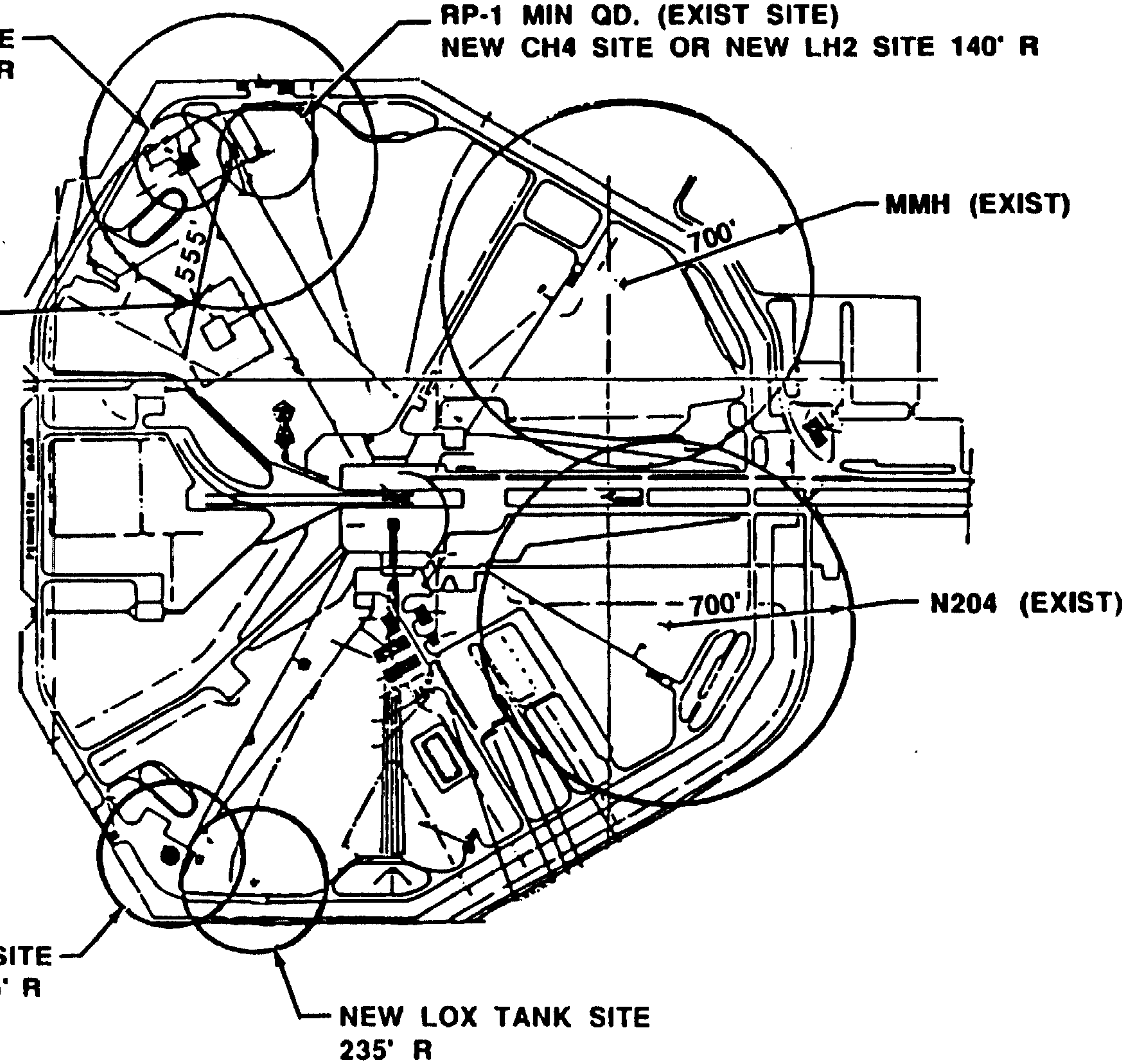
THIS STUDY PRODUCT ASSESSES THE PROPELLANT REQUIREMENTS OF THE VARIOUS LIQUID ROCKET BOOSTERS (LRB's). THE STUDY DETERMINED THE STORAGE REQUIREMENTS, DEFINED SCRUB/TURNAROUND OPTIONS, AND PROVIDES DESIGN CONCEPTS FOR THE LOADING SYSTEMS. THE ANALYSES OF LRB REQUIREMENTS AND LOADING CONCEPTS PROVIDE A RATIONALE FOR ACQUISITION, STORAGE, AND HANDLING AND PROVIDE A DEFINITION OF THE REQUIRED PROPELLANT GROUND SYSTEM.

THE PROPELLANTS REVIEWED INCLUDE LIQUID OXYGEN (LOX), LIQUID HYDROGEN (LH_2), ROCKET GRADE KEROSENE (RP1), AND LIQUID METHANE (LCH_4).

THE BASELINED LRB IS THE LOX/RP1 CONFIGURATIONS AND A REVIEW OF THE SYSTEM REQUIREMENTS ARE PRESENTED.

THE PRESENT PAD PROPELLANT STORAGE AREAS WILL BE UTILIZED.

PROPELLANT DIS ANCE REQUIREMENTS



LIQUID OXYGEN SYSTEM

THE ANALYSIS OF THE LRB LOX REQUIREMENTS IS BASED ON DATA PROVIDED BY GENERAL DYNAMICS AND MARTIN MARIETTA, KNOWN EXTERNAL TANK (ET)/SPACE SHUTTLE MAIN ENGINE (SSME) PROCESSING OPERATIONAL DATA, AND PRESENT SPACE SHUTTLE VEHICLE (SSV) INTERFACE CONTROL REQUIREMENTS. THE SIX LRB CONFIGURATIONS WERE ANALYZED TO DEFINE FILL AND DRAIN REQUIREMENTS, INCLUDING ANTICIPATED BOILOFF LOSES. SCRUB/TURNAROUND OPTIONS WERE DEFINED. LOX STORAGE AND ACQUISITION REQUIREMENTS WERE EVALUATED. A DESCRIPTION OF A LRB LOX FACILITY WAS DEVELOPED.

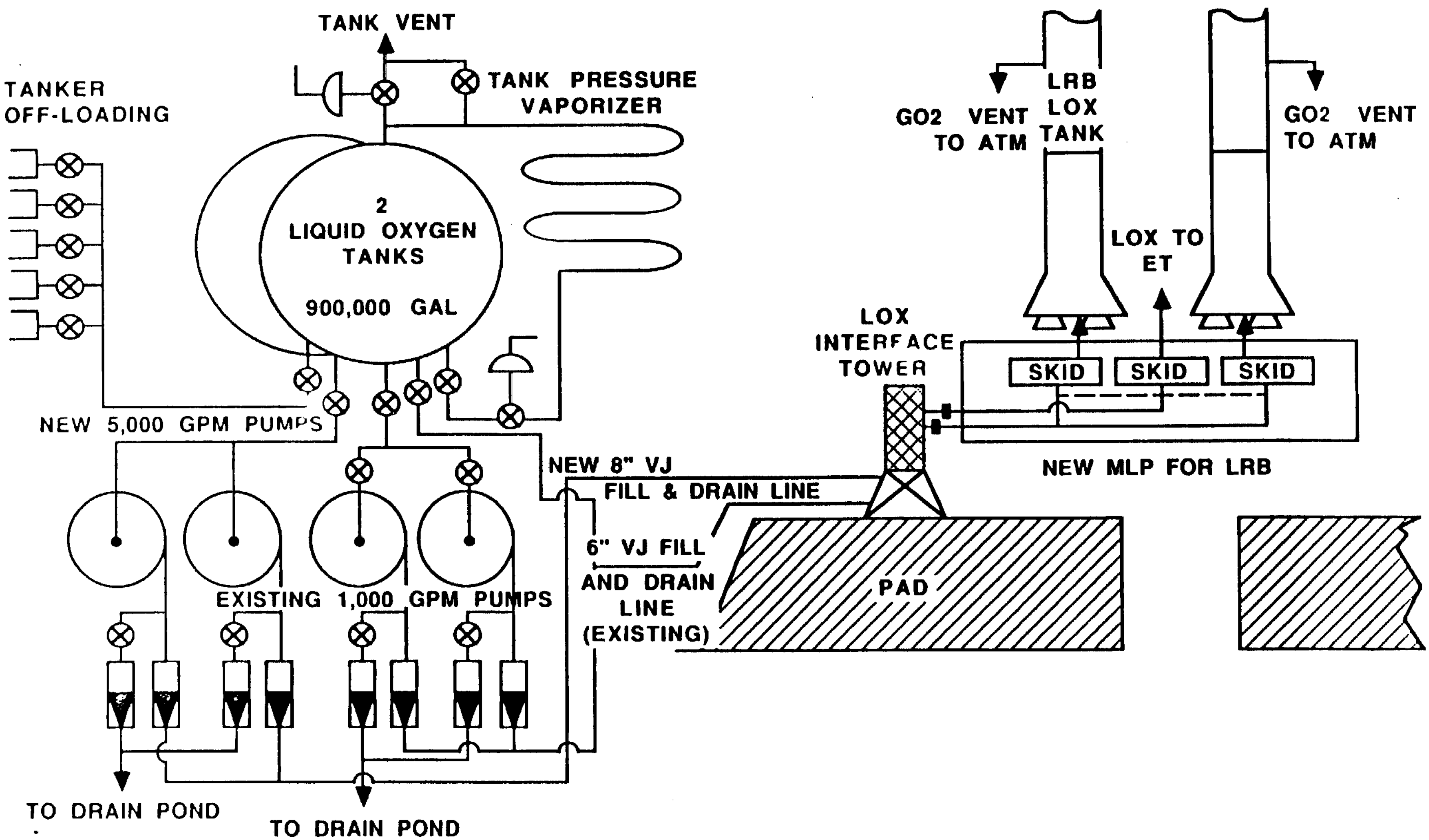
CONCEPT: PROVIDE A NEW 5000-GPM VARIABLE PUMP AND 8 INCH TRANSFER LINE FOR THE LRB. THIS CONCEPT DOES NOT CHANGE ANY OF THE EXISTING MPS OPERATIONAL PROCEDURES.

THE CONCEPT WILL REQUIRE A SECOND 900,000-GALLON STORAGE VESSEL TO MEET TURNAROUND REQUIREMENTS WITHOUT STORAGE VESSEL REFILL. ALSO IN THE RECOMMENDED DESIGN IS THE CAPABILITY TO OFFLOAD 10 TANKERS AT A TIME INSTEAD OF THE PRESENT 5.

CONCLUSION/RECOMMENDATIONS

THE EXISTING LOX FACILITY CANNOT MEET PROGRAM REQUIREMENTS FOR SCRUB/TURNAROUND WITH LRB IN 24 HOURS; THEREFORE, DOUBLING THE FACILITY SIZE IS REQUIRED. ALSO INCLUDED IN THE RECOMMENDATION IS THE DOUBLING OF THE TANKER FLEET SO THAT NUMBER OF SHIFTS REQUIRED TO FILL THE STORAGE VESSEL IS REDUCED.

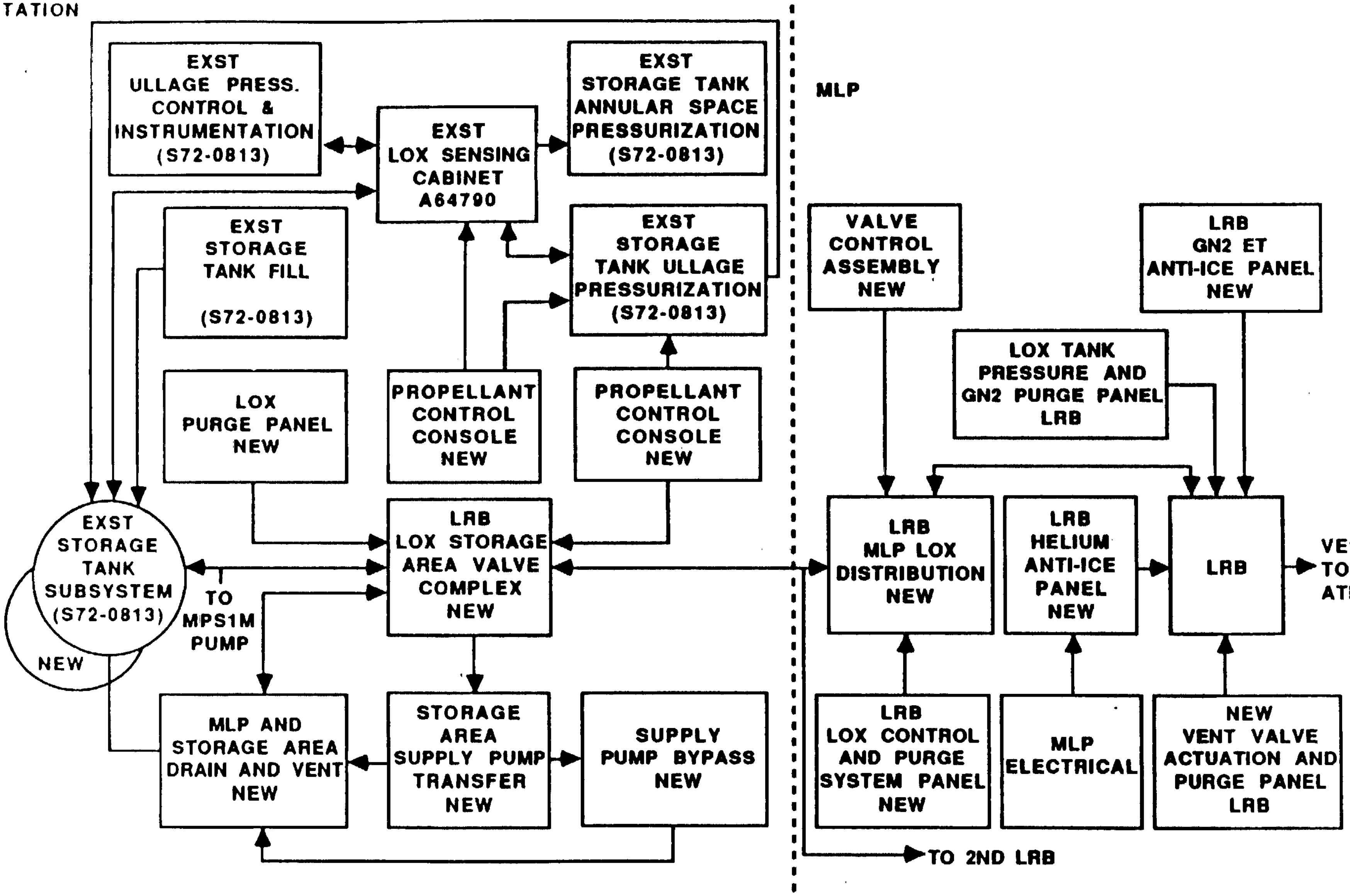
LIQUID OXYGEN SERVICING SYSTEM



LRB LOX SYSTEM FLUID GSE REQUIREMENTS FOR PAD/MLP

THE PNEUMATIC SYSTEM WILL INCLUDE NITROGEN AND HELIUM PNEUMATIC DISTRIBUTION SYSTEMS. NITROGEN IS USED FOR REMOTE OPERATION OF VALVES AND IN THE PURGE SYSTEM TO PROTECT FACILITY LINES, COMPONENTS, AND EQUIPMENT FROM MOISTURE AND CONTAMINATION. NITROGEN IS SUPPLIED FOR BLANKET PRESSURE WHEN THE LOX SYSTEM IS IN STANDBY CONFIGURATION, AND FOR LEAK CHECKS OF SYSTEM CONNECTIONS. HELIUM IS USED FOR LRB LOX TANK ANTI-GEYSERING, PREPRESSURIZATION AND VENT VALVE OPENING ACTUATION. IT IS ALSO USED FOR LRB UMBILICAL ANTI-ICING.

LO2 SYST Λ BLOCK DIAGRAM



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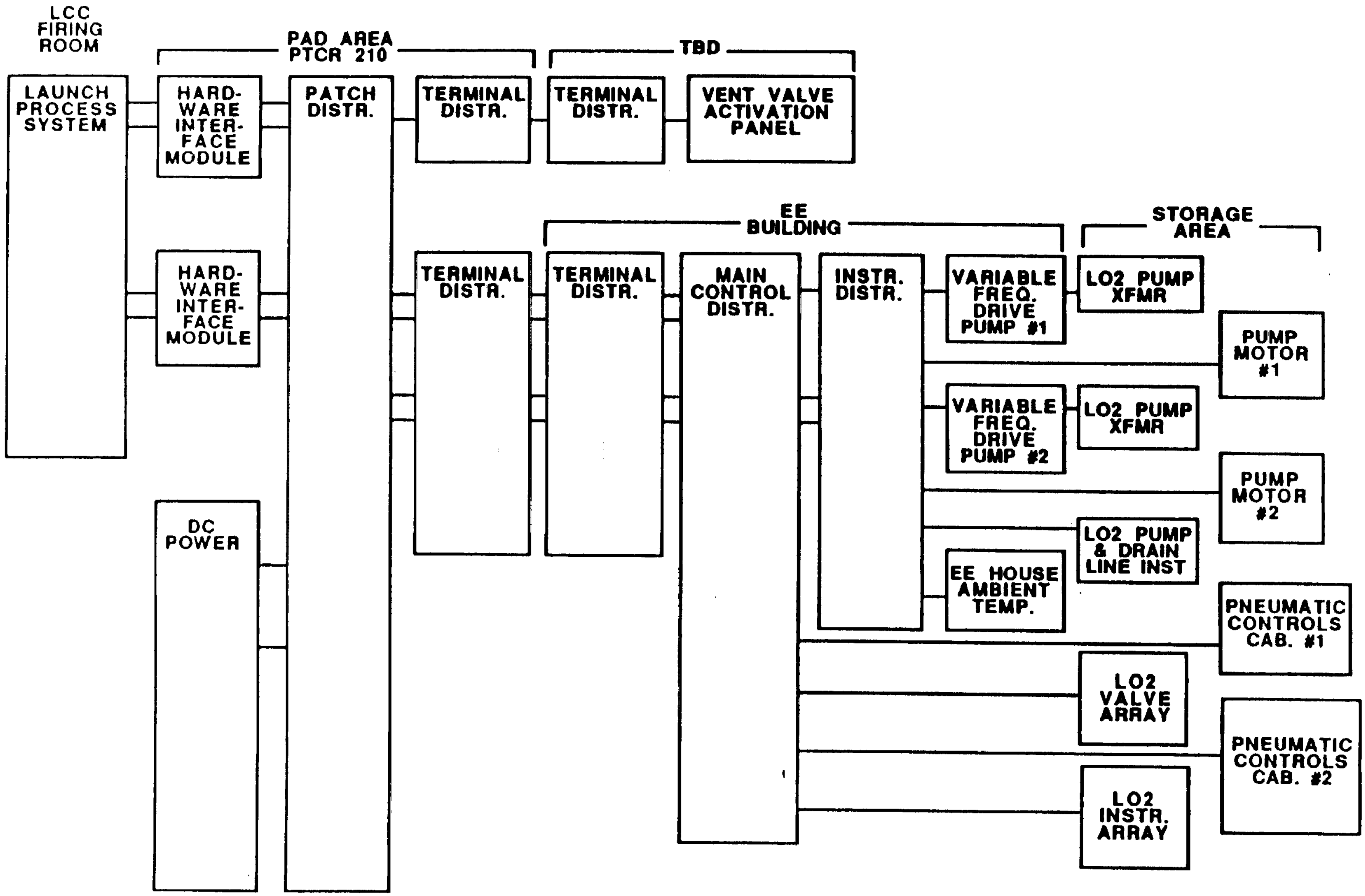
LO2 GSE ELECTRICAL CONTROLS (LAUNCH PAD)



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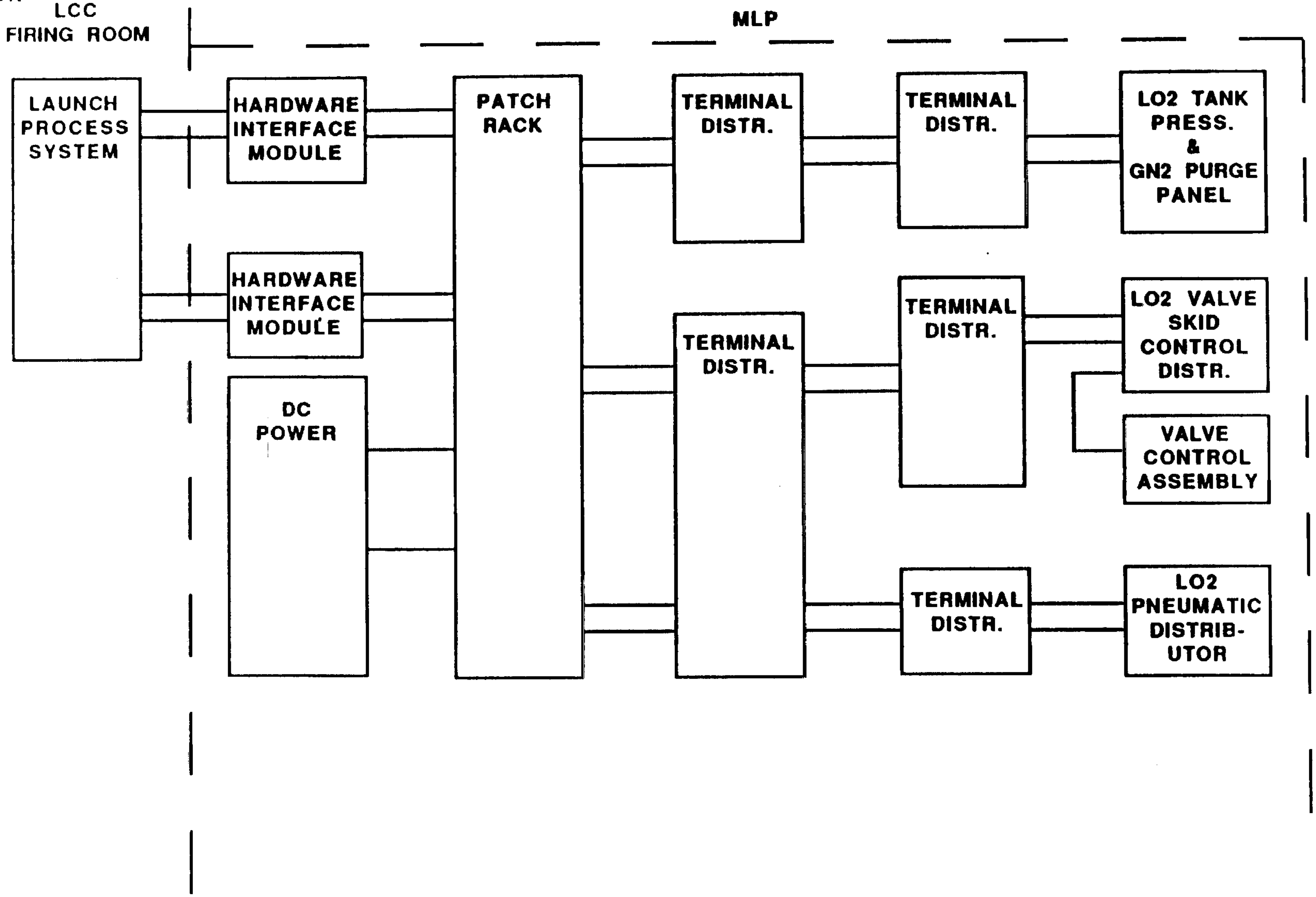
LO2 GSE MLP ELECTRICAL CONTROLS



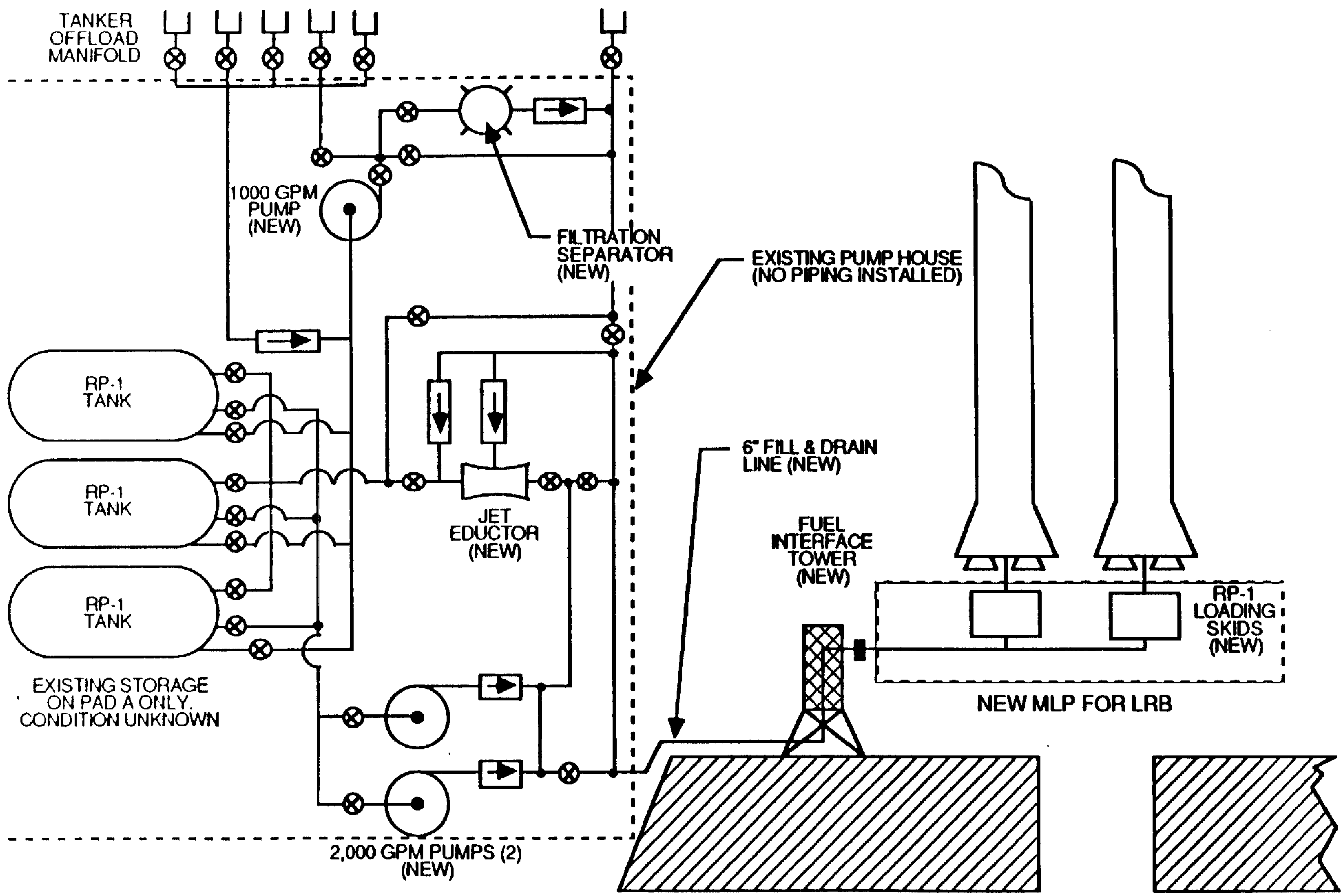
RP1 SYSTEM

THE GDSS AND MMC LOX/RP1 DATA YIELDS FOUR CONFIGURATIONS/OPTIONS FOR THE LOX/RP1 SYSTEM. THESE OPTIONS INVOLVE THE USE OF EITHER PUMP- OR PRESSURE-FED LIQUID ROCKET BOOSTERS. ALSO INCLUDED IN THIS STUDY IS AN EVALUATION OF THE TRANSFER METHOD FROM STORAGE TO VEHICLE.

DUE TO THE PHYSICAL PROPERTIES OF RP1, TRANSFER AND STORAGE FACILITIES WILL NOT INVOLVE A MASS LOSS OF RP1 (SUCH AS BOILOFF). THIS SIMPLIES A SCRUB/TURNAROUND OPERATION, AND NO ADDITIONAL STORAGE SPACE WOULD BE REQUIRED ABOVE THAT NECESSARY TO SUPPORT THE VEHICLE AND MAINTAIN THE REQUIRED MASS STORAGE CAPABILITY. ONE OF THE ADVANTAGES OF RP1/LOX IS THE EXPERIENCE GAINED DURING THE APOLLO PROGRAM. A NEW BASELINE WOULD BE REQUIRED, AND A REBIRTH OF THE APOLLO DOCUMENTATION AND PROCEDURES SHOULD PROVE SUFFICIENT. THERE ARE STILL SOME EXISTING INSTALLATIONS INVOLVING RP1, SUCH AS STORAGE FACILITIES ON PAD A; HOWEVER, THESE FACILITIES HAVE BEEN ABANDONED IN PLACE AND TO ASSUME THEIR USABILITY WOULD BE UNREALISTICALLY OPTIMISTIC. TO PRESUME THE WORST, THE RP1 SYSTEM WOULD REQUIRE THE INSTALLATION OF AN ENTIRELY NEW STORAGE AND TRANSFER MECHANISM.

DESIGN CONCEPT FOR PUMP TRANSFER

THE USE OF A PUMP-FED RP1 SYSTEM INVOLVES THE INSTALLATION OF A NEW TRANSFER (AND PROBABLY STORAGE) FACILITY AT KSC. THREE 85,000-GALLON STORAGE TANKS WOULD HOLD THE RP1, WHILE A REDUNDANT TWO-PUMP SYSTEM WILL PROVIDE THE MOTIVE FORCE. A NEW EDUCTOR SYSTEM WOULD AID THE HYDRAULIC PRESSURES IN THE EVENT A SCRUB TURNAROUND WAS REQUIRED. FINALLY, THE SECONDARY 1,000 GPM-PUMPING SYSTEM WOULD PROVIDE A PURIFICATION CAPACITY AS REQUIRED.



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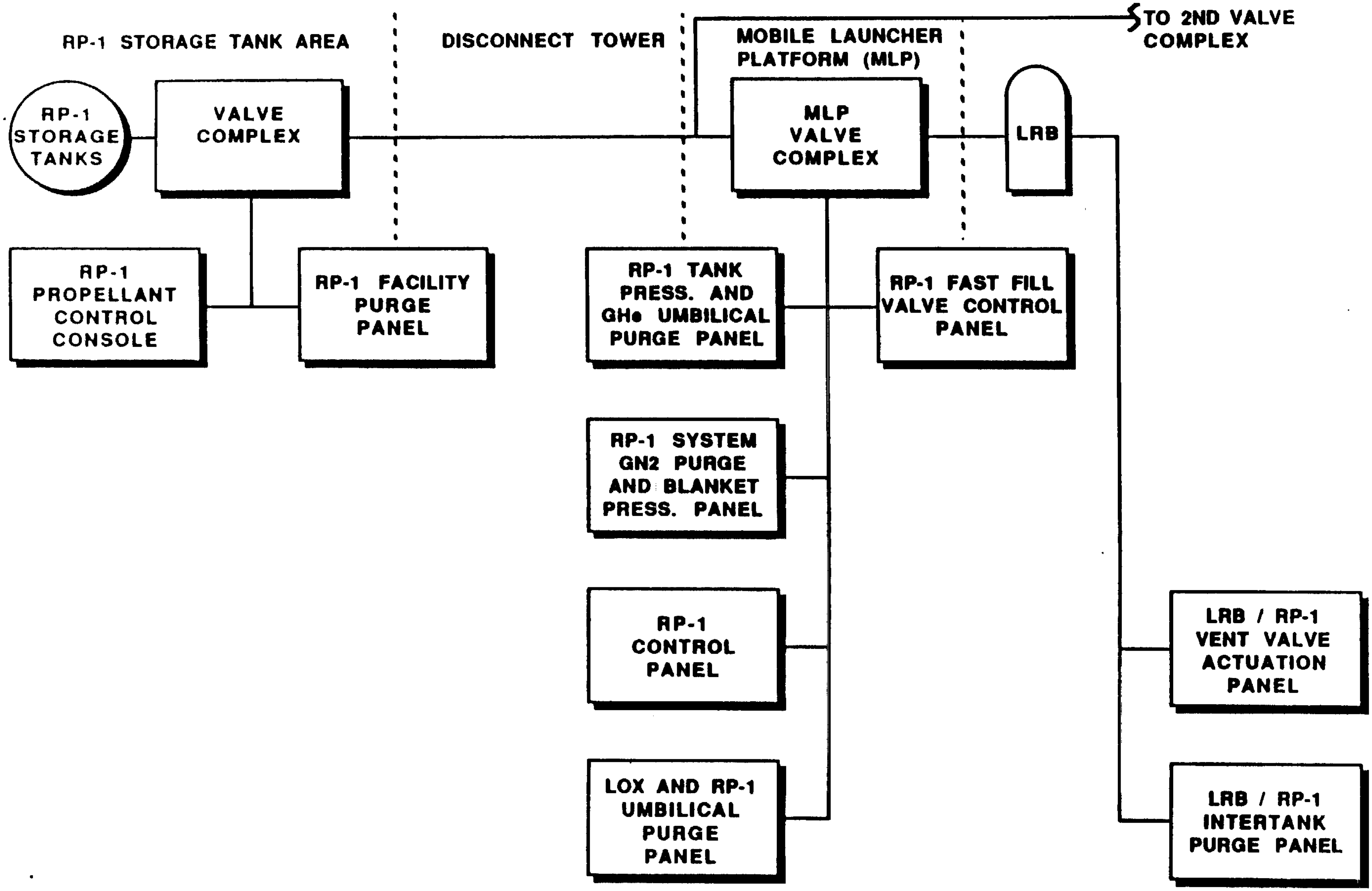
RP1 SYSTEM FLUID GSE REQUIREMENTS FOR PAD/MLP

THIS REPORT ASSUMES THAT THE LRB RP1 SYSTEM WILL BE SIMILAR TO THE APOLLO RP1 PROPELLANT LOADING SYSTEM. THE PROPELLANT WILL BE STORED AT THE LAUNCH PAD AND BE TRANSFERRED TO THE VEHICLE FUEL TANK USING PUMPS.

THE VALVE COMPLEXES WILL REQUIRE CONTROL PANELS AND CONSOLES CONSISTING OF PNEUMATICALLY OPERATED VALVES TO PROVIDE CONTROL OF THE TRANSFER COMPONENTS, OPERATE THE LRB RP-1 TANK VENT VALVES, PRESSURIZE THE VEHICLE RP1 TANK IN PREPARATION FOR FLIGHT, AND PROVIDE BLANKET PRESSURES FOR THE SYSTEM FOR MOISTURE PROTECTION WHEN THE SYSTEM IS NOT IN USE.

THE BLOCK DIAGRAM DEPICTING THESE SYSTEMS IS DESCRIBED HERE.

LRB RP-1 SYSTEM BLOCK DIAGRAM



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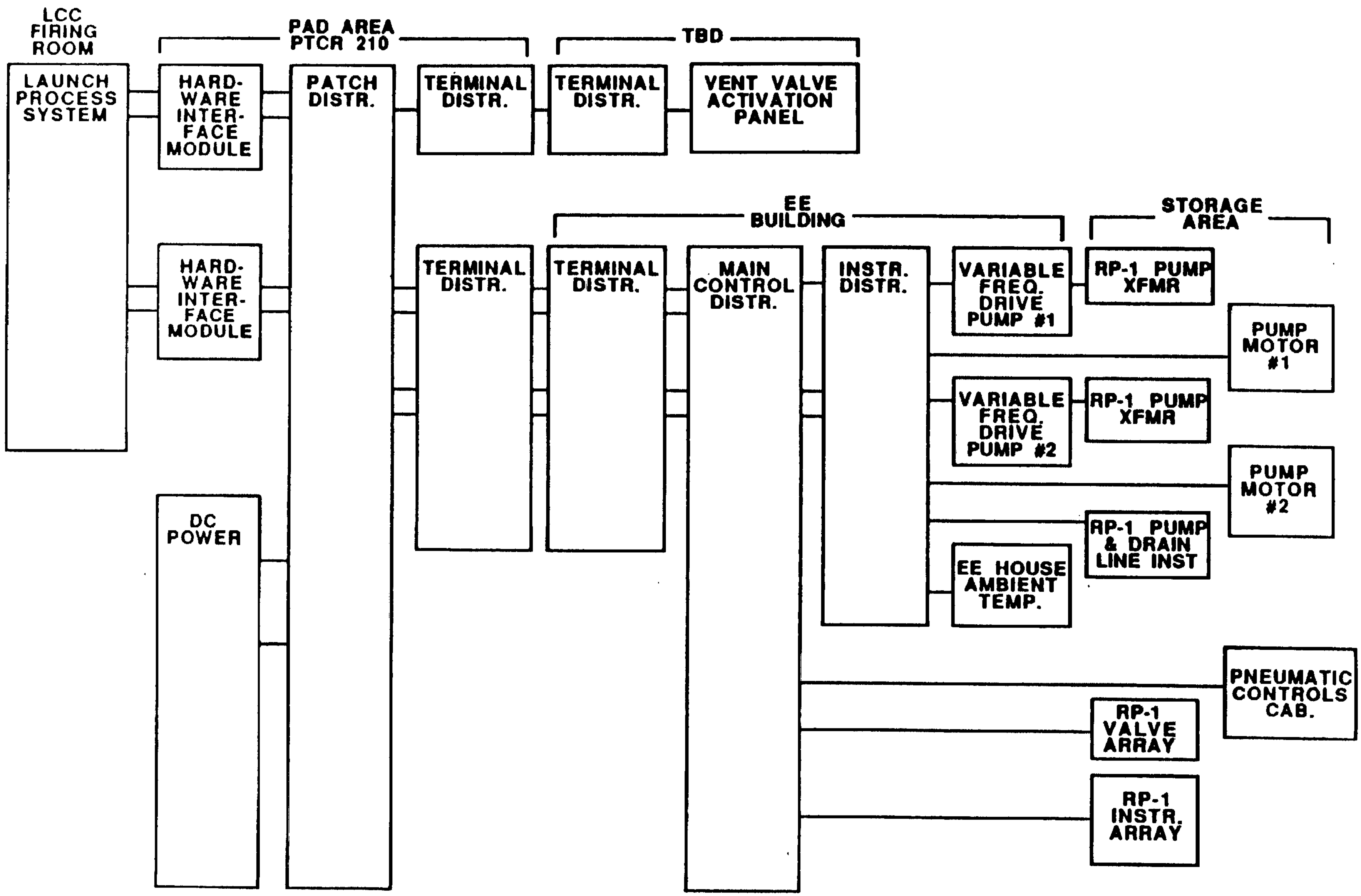
RP-1 STORAGE GSE ELECTRICAL CONTROLS (LAUNCH PAD)



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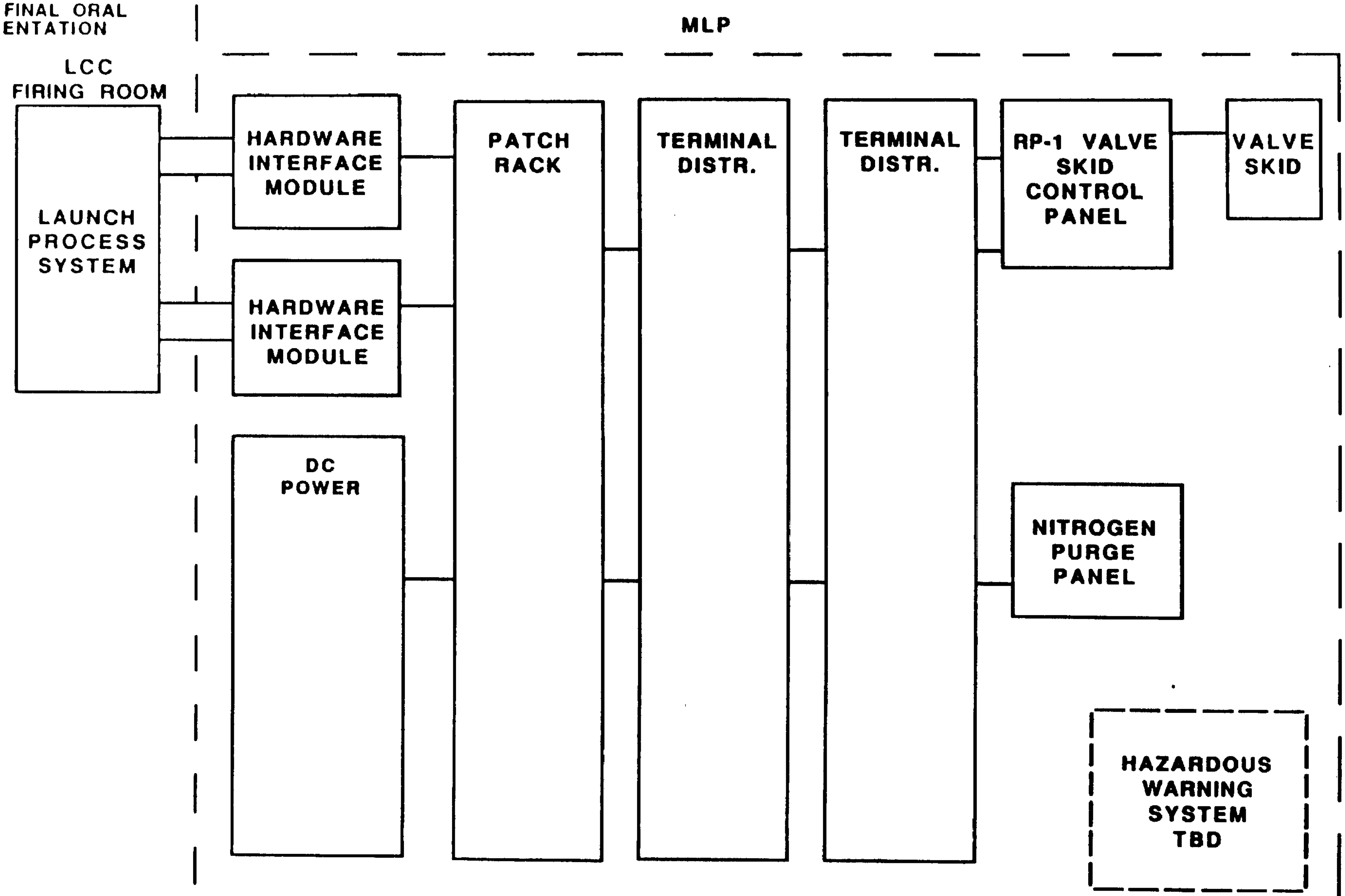
RP-1 GSE MLP ELECTRICAL CONTROLS



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COMPARISON OF LH2 VS RP-1 LRB

THE LRB's USED AS A BASELINE TO STUDY THE KSC IMPACTS WAS THE LOX/RP-1 CONFIGURATIONS FROM BOTH CONTRACTORS. THIS CHOICE OF CONFIGURATION ALLOWED THE COMPARISON OF APPLES AND APPLES AND WAS NOT INTENDED TO ADVOCATE RP-1 AS A FUEL. THE FUEL CHOICE AT THE LAUNCH SITE FOR ANY FUTURE PROPULSION SYSTEM IS LIQUID HYDROGEN. ALTHOUGH THE GDSS LOX/LH2 CONFIGURATION HAS FACILITY IMPACTS WHICH ARE MORE EXTENSIVE THAN THE FOUR LOX/RP-1 CONFIGURATIONS (SEE SECTION 3), FROM A PROPELLANT POINT OF VIEW THE LH2 LRB's ARE PREFERRED.

TO COMPARE LH2 WITH THE RP-1 SYSTEM, A LH2 SYSTEM WOULD BE MORE EXPENSIVE TO IMPLEMENT BUT THE BENEFITS OUT WEIGHT THE COST. THE INTANGIBLES INCLUDE ENVIRONMENTAL IMPACTS (EMISSION - AIR QUALITY, POLLUTION - GROUND WATER (QUALITY), AVAILABILITY, ENGINE REQUIREMENTS AND SYSTEM MAINTENANCE.

FROM A HAZARD POINT OF VIEW LH2 VAPOR IS MORE HAZARDOUS THAN RP-1 VAPOR BUT THE SAFETY SYSTEM FOR H2 CURRENTLY EXISTS AND THE ENVIRONMENTAL IMPACTS ARE LOW.

ALL LRB CONFIGURATIONS POSE FACILITY IMPACTS (ACCESS, UMBILICAL REDESIGNS, FLAME DEFLECTOR REDESIGNS) WHICH MUST BE SOLVED WITH ENGINEERING AND OPERATIONAL CHANGES. THE TALLER LOX/LH2 LRB WILL INTERFERE WITH THE GOX VENT ARM (THIS PROBLEM EXISTS WITH THE LOX/RP-1 GDSS PRESS FED CONFIGURATION ALSO. THIS IMPACT TO THE GOX VENT ARM CAN BE SOLVED EITHER WITH A CONFIGURATION CHANGE TO THE VENT ARM OR A DESIGN CHANGE TO THE ET.

EVEN WITH THE FACILITY IMPACTS THE VERSATILITY OF LH2 IS FAR SUPERIOR TO RP-1 FOR LAUNCH VEHICLE PROGRAMS OF THE FUTURE.

COMPARISON OF LH2 vs RP-1

	RP-1	LH2
NON-RECURRING COST	LEAST @ $6.6M	MOST @ $25.9M
RECURRING COSTS INCLUDE	• PUMP MAINTENANCE • GROUND WATER MONITORING • AIR QUALITY MONITORING • NEW ENGINEERING STAFF	• VJ EQUIP / VESSEL MAINTENANCE • H2 MONITORING
TECHNOLOGY / SYSTEM	• NEW INSTALLATION • NEW SUPPORT / SAFETY SYSTEM	• MODIFY EXISTING SYSTEM
COMMODITY COST / LAUNCH (SUCCESSFUL - NO SCRUB)	WORST LRB $348,000 (1) BEST LRB $261,000 (2)	$455,000
ACQUISITION - COST MADE FROM	$3.00/GALLON PETROLEUM	$1.00 / GALLON NATURAL GAS, PETROLEUM
AVAILABILITY TRANSPORTATION	LIMITED NEW FLEET	EXPANDING EXISTING FLEET

NOTES: (1) GDSS PRESSURE (2) MMC PUMP (3) GDSS LOX / LH2 (4) GDSS FATBIRD (5) GDSS PUMP (6) MMC PRESSURE

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COMPARISON OF LH2 vs RP-1 (CONT)

	RP-1	LH2
EXHAUST	• ENVIRONMENTALLY DIRTY • HOTTER THAN LOX / LH2	• ENVIRONMENTALLY CLEAN
ENGINE SERVICING	• FLUSH / GUSH WITH WATER GLYCOL • INSTALLATION OF PROPELLANT IGNITION CARTRIDGES	
HAZARD	LOW VAPOR IGNITION HAZARD	HIGH IGNITION POINT HAZARD
LRB SITE - SHIRT DIAMETER	WORST 26.8' (1) BEST 22.1' (2)	WORST 24.4' (1) BEST 22.3' (3)
LENGTH	WORST 195.7' (1) BEST 148.8' (5)	WORST 191.0' (3) BEST 169.5' (4)
DIAMETER	WORST 16.2' (6)	WORST 17.7' (4)

NOTES: (1) GDSS PRESSURE (2) MMC PUMP (3) GDSS LOX / LH2 (4) GDSS FATBIRD (5) GDSS PUMP (6) MMC PRESSURE

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LAUNCH AD CONCLUSIONS

- SIDE DEFLECTOR ACTS AS AN EXTENSION OF FLAME TRENCH
  - FLAME IMPINGEMENT
- MULTI-BOOSTER (LRB / SRB) MAIN DEFLECTOR REQUIRED
- NEW ACCESS REQUIRED
- ACCESS ABOVE PCR ROOF NOT AVAILABLE
- EXISTING UMBILICALS / MECHANISMS REQUIRE REDESIGN AND LETF TESTING
  - MAJOR IMPACT TO ET H2 VENT DUE TO DIAMETER
  - GOX VENT IMPACT DUE TO LENGTH
- NEW LRB UMBILICALS REQUIRED
- WEATHER PROTECTION SYSTEM REQUIRES REDESIGN
- NEW PROPELLANT STORAGE REQUIRED
- NEW GSE REQUIRED

FIRING ROOM LPS REQUIREMENT FOR LRB

THE LPS HARDWARE IMPACTS AND THE ADDITIONAL LRB SOFTWARE AND OPERATIONAL REQUIREMENTS WILL HAVE SIGNIFICANT AFFECT ON THE USERS OF THE CCMS AND THE RECORD AND PLAYBACK SYSTEM (RPS). THE INTRODUCTION OF LRB REQUIREMENTS WILL ENTAIL THE NEED FOR ADDITIONAL CONSOLES IN THE FIRING ROOMS AND CHANGES TO THE CCMS SYSTEM SOFTWARE.

TO ACCOMMODATE LRBs DURING LAUNCH COUNTDOWN NEW APPLICATION SOFTWARE WILL BE REQUIRED. EACH OF THE FIRING ROOMS WILL REQUIRE ADDITIONAL LPS HARDWARE. EACH OF THE FOUR FIRING ROOMS WILL NEED: THREE NEW LPS TYPE-1 CONSOLES, AND EITHER TWO OR FOUR NEW PCM-TYPE FEPs, DEPENDING ON WHETHER OR NOT THE LRB PCM DATA COMES INDEPENDENTLY FROM THE ORBITER 128 KB PCM. REALLOCATION OF THE EXISTING BOOSTER TEST CONDUCTOR PERSONNEL AND SOFTWARE WILL ALSO BE NECESSARY.

TO ACCOMMODATE NEW COMMAND TYPES, DATA STREAMS, AND DATA TYPES REQUIRED BY LRB SYSTEMS, APPROXIMATELY 900,000 LINES OF CCMS SYSTEM SOFTWARE WILL BE REQUIRED. FURTHER STUDY WILL BE REQUIRED TO DETERMINE THE IMPACT OF EXCEEDING THE CURRENT LIMITATION OF FIFTEEN CONSOLES IN A FIRING ROOM.

THE EXISTING CCMS EQUIPMENT IN THE FIRING ROOMS WILL NOT SUPPORT THE EXPANSION NEEDED TO SUPPORT LRBs. NO EQUIPMENT OF THIS TYPE IS AVAILABLE, LPS 2 WILL BE NECESSARY FOR THE UPGRADE OF THE FIRING ROOM CCMS EQUIPMENT. THIS PROPOSED USE OF LPS 2 EQUIPMENT SHOULD BE FEASIBLE BECAUSE THE TIMELINES FOR LPS 2 DEVELOPMENT VERY CLOSELY MATCH THOSE PROJECTED FOR THE LRB.

LINES OF CCMS SOFTWARE REQUIRED

SYSTEM	LINES AFFECTED
SYSTEM BUILD	250,000
EXECUTORS	100,000
OPERATING SYSTEM	100,000
FEP	150,000
RETRIEVAL	200,000
CONSOLE	50,000
SGOS	100,000
RPS	100,000
TOTAL	950,000

LPS APPLICATION SOFTWARE REQUIREMENTS FOR LRB

THE LPS APPLICATIONS SOFTWARE ASSESSMENT WAS BASED ON A PERCENTAGE OF EXISTING SOFTWARE EXPECTED TO CHANGE OR BE ADDED AS A RESULT OF SWITCHING TO A LIQUID ROCKET BOOSTER. THE EXISTING FIRING ROOM APPLICATION SOFTWARE WAS REVIEWED BY USING EQUIVALENT SHUTTLE SYSTEMS TO REPRESENT THE LRB ONBOARD SYSTEMS, AS WELL AS KNOWLEDGE OF EXISTING GSE, PROCEDURES, AND OPERATING METHODS. SGOS MODELS USED TO PERFORM SOFTWARE VERIFICATION AND VALIDATION WERE ESTIMATED IN THE SAME MANNER. THE EXPECTED CONFIGURATIONS OF THE VARIOUS SYSTEMS AND SUBSYSTEMS WERE ESTIMATED BY COMPARATIVE ANALYSES TO SIMILAR SYSTEMS ABOARD THE ORBITER. RELATIVE NUMBERS OF CONSOLE DISPLAY USED DURING THE DIFFERENT TESTS PERFORMED ON THE SHUTTLE DURING BOTH PROCESSING AND LAUNCH COUNTDOWN WERE ASSESSED.

THE OPERATIONAL PHILOSOPHY AND CURRENT ASSIGNMENTS OF SYSTEM RESPONSIBILITIES WITHIN THE FIRING ROOM MAKE IT FEASIBLE FOR ALL SYSTEMS TO BE OPERATED AND MONITORED BY PERSONNEL CURRENTLY PERFORMING THESE TASKS ON THE ORBITER, ET, AND SRBs, WITH THE EXCEPTION OF LRB ENGINES AND PROPELLANT SYSTEMS.

THE GROUND LAUNCH SEQUENCER (GLS) IS AN EXCEPTIONALLY TIME CRITICAL SET OF APPLICATION SOFTWARE. THE EFFECTS OF ADDING EIGHT NEW ENGINES AND THEIR IMPACTS ON THE TERMINAL COUNTDOWN, ABORT, AND SAFING PROCEDURES WILL NECESSITATE THE REWRITE OF THE ENTIRE GLS TO INCLUDE LRBs.

APPROXIMATELY 900,000 LINES OF CODE WILL HAVE TO BE WRITTEN OR MODIFIED TO INCORPORATE LRBs INTO FIRING ROOM APPLICATION SOFTWARE. IN ADDITION THERE WILL BE APPROXIMATELY 1,000 NEW OR MODIFIED DISPLAY SKELETONS THAT WILL BE REQUIRED.

DELTA _INES OF CODE

SYSTEM	EXISTING	% DELTA	LINES DELTA
EPDC	52,599	95%	49,969
TAVC	40,540	95%	38,523
INST	8,286	95%	7,862
RSS	16,298	95%	15,483
RP-1	35,076	95%	33,322
LO2	36,448	95%	34,625
ETCO	15,202	95%	14,442
ENGINES	121,004	95%	114,954
UMBILICALS	10,094	25%	2,523
GNC	275,084	35%	131,280
DPS	21,868	40%	8,750
INTG	4,638	95%	4,406
COMM	21,320	25%	5,330
HAZGAS	16,800	30%	5,040
FSW	20,117	20%	4,024
GLS	100,000	100%	100,000
CCS	1,500,000	10%	150,000
ESA	160,000	50%	80,000
MODELS	200,000	50%	100,000
TOTAL	2,655,374	34%	900,533

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LAUNCH CONTROL CENTER CONCLUSIONS

- 950,000 LINES OF CODE FOR CCMS REQUIRED
- 900,533 ADDITIONAL LINES OF CODE REQUIRED FOR APPLICATION SOFTWARE

C-5 SUBSTATION AND EMERGENCY GENERATOR

THE POWER REQUIREMENTS OF ALL LC-39 FACILITIES WILL RESULT IN THE NEED FOR 12 NEW 13.8 kV FEEDERS FROM THE C-5 SUBSTATIONS. THE C-5 SUBSTATION IS AT OR NEAR CAPACITY AT THIS TIME. ADDITIONAL SWITCHES AND TRANSFORMERS WILL BE REQUIRED IN THE SWITCHYARD TO ACCOMMODATE THIS NEW CAPACITY.

THERE WILL BE FIVE NEW 480 V ac FEEDERS REQUIRED FROM THE C-5 EMERGENCY GENERATORS. SUFFICIENT GENERATOR CAPACITY EXISTS TO SUPPORT THE ADDITIONAL POWER LOADS RESULTING FROM THE ADDITION OF EMERGENCY SUBSTATIONS. TRANSFORMER CAPACITY IN THE EXISTING GENERATOR BUILDING WILL BE EXCEEDED AND THEREFORE TWO NEW TRANSFORMERS WILL BE REQUIRED TO ACCOMMODATE THE NEW EMERGENCY FEEDERS. THE EXISTING CABLE TRENCHES ARE AT CAPACITY.

TO SUPPORT THE ADDITION OF NEW FEEDERS, SOME NEW MANHOLES, CABLE TRENCHES, AND DUCT BANKS WILL BE REQUIRED.

LC-39 POWER REQUIREMENTS

SITE	FACILITY 60 HZ POWER	EMERGENCY GENERATOR 60 HZ POWER	UPS	FIBER DATA LINKS
LRB AT ET PROCESSING FACILITY	4-13.8KV FEEDERS 2-2000 AMP SUBSTATION (DOUBLE ENDED)	1-480V @ 400 AMP FEEDER	1-600KVA @ 480V	N/R
MLP PARK SITE	2-13.8KV FEEDERS	1-480V @ 400 AMP FEEDER	N/R	20-LCC
PAD A LOX	1-13.8KV FEEDER 1-2000 AMP SUBSTATION	N/R	N/R	3-LCC
PAD A FUEL	1-13.8KV FEEDER 1-2000 AMP SUBSTATION	N/R	N/R	3-LCC
PAD B LOX	1-13.8KV FEEDER 1-2000 AMP SUBSTATION	N/R	N/R	3-LCC
PAD B FUEL	1-13.8KV FEEDER 1-2000 AMP SUBSTATION	N/R	N/R	3-LCC
LCC	N/R	N/R	N/R	54
VAB HI-BAY 4 (ALL NEW)	2-13.8KV FEEDERS	1-480V @ 400 AMP FEEDER	N/R	20-LCC
C-5 POWER STATION C-5 EMERGENCY GENERATORS	12-200 AMP @13.8KV FEEDERS	3-400V @ 480 AMP FEEDERS	N/R	12-LCC

LIQUID ROCKET BOOSTER INTEGRATION

AGENDA

I. INTRODUCTION	Gordon Artley
II. LRBI RESULTS	
BASELINE / LAUNCH SITE SCENARIO	Pat Scott
FACILITIES AND GROUND SYSTEMS	Greg DeBlasio
IMPLEMENTATION	Gordon Artley
COST	Jerry Lefebvre
III. SUMMARY	Gordon Artley

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LRBI IMPLEMENTATION

- LAUNCH SITE PLAN
- TRANSITION OVERVIEW
- DOCUMENTATION REQUIREMENTS
- MANPOWER
- PROGRAM OPERATING PLAN
- VLS

LRB LAUNCH SITE PLAN

THE LRB LAUNCH SITE PLAN PRESENTS AN IMPLEMENTATION CONCEPT FOR INTEGRATION OF THE NEW BOOSTER ELEMENT INTO THE STS. THIS PLAN SATISFIES THE PHASE-A STUDY GROUND RULE OF MINIMIZING OR ELIMINATING SRB/STS OPERATIONAL IMPACTS DURING LRB IMPLEMENTATION. IN ADDITION, AT THE CONCLUSION OF THE TRANSITION PHASE, SRB/STS OPERATIONAL CAPABILITY IS RETAINED.

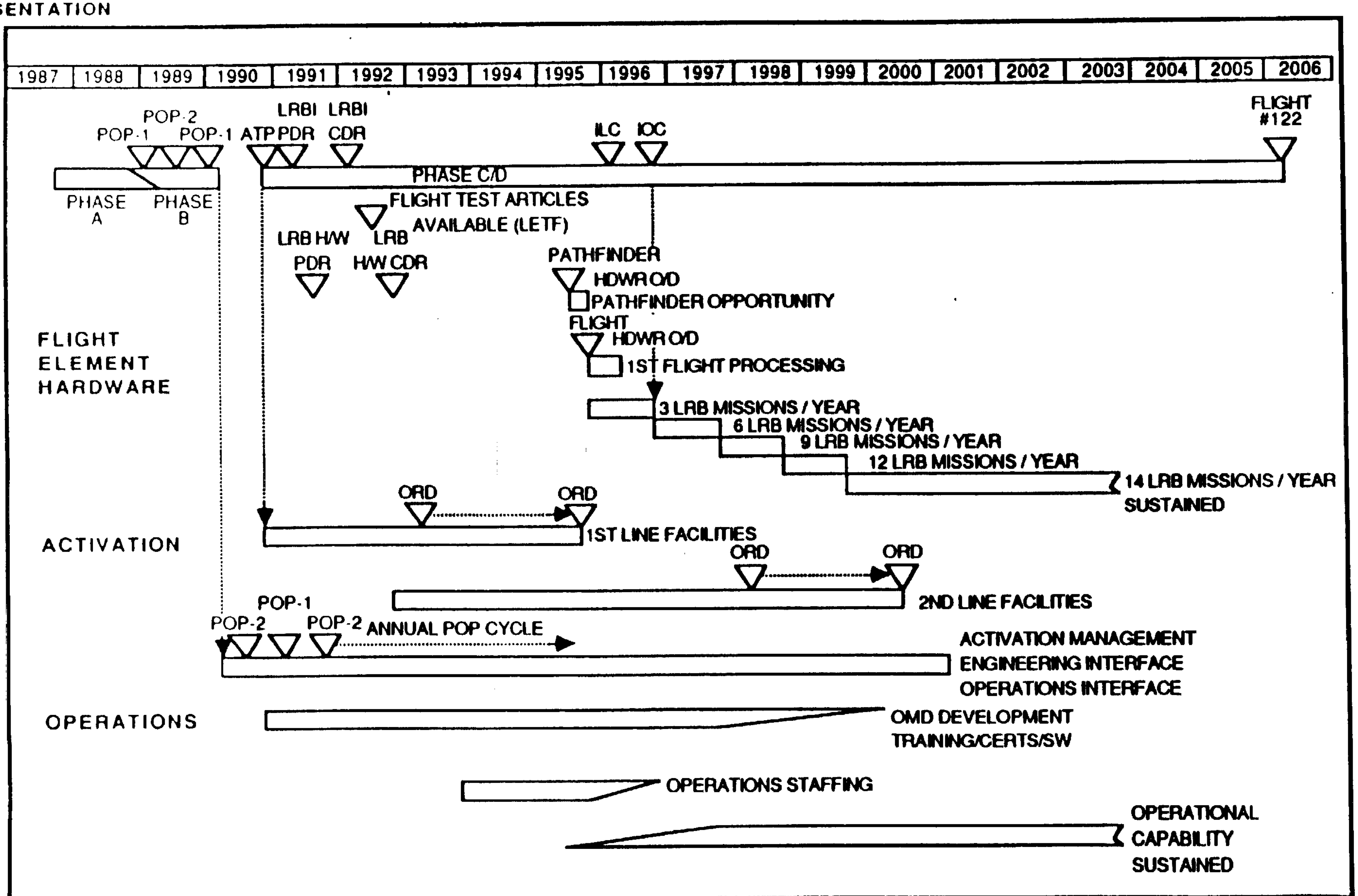
THIS PLAN SPANS A PERIOD OF APPROXIMATELY 15 YEARS, FROM PHASE C/D AUTHORITY TO PROCEED THROUGH LRB MISSION #122 AND CONSISTS OF THREE NON-AUTONOMOUS LAUNCH SITE PHASES; ACTIVATION, TRANSITION AND OPERATIONS. THESE PHASES ARE INTEGRATED WITH THREE DISCRETE PROGRAM ASPECTS: FUNDING, MULTI-CENTER DESIGN DEVELOPMENT, AND THE FLIGHT ELEMENT HARDWARE DELIVERY TO THE LAUNCH SITE.

ACTIVATION INCLUDES THE END-TO-END IMPLEMENTATION OF THE 1ST LINE FACILITIES, REQUIRED TO SUPPORT THE PROPOSED LRB PATHFINDER PROGRAM AND ILC; AND THE 2ND LINE FACILITIES, REQUIRED AS THE LRB FLIGHT RATE RAMPS UP.

TRANSITION IS EFFECTIVELY THE 5 YEAR PERIOD OF MIXED-FLEET PROCESSING ACTIVITY OF SRB AND LRB FLIGHT HARDWARE.

THE OPERATIONAL PHASE EXTENDS OVER THE 15 YEAR PROGRAM DURATION, INITIATING WITH SUPPORT TO THE ACTIVATION DESIGN DEVELOPMENT, PROCEEDING WITH STAFFING AND TRAINING, AND CONCLUDING WITH FULL OPERATIONAL CAPABILITY SUPPORTING A SUSTAINED LRB FLIGHT RATE OF 14 MISSIONS PER YEAR.

LRB LAUNCH SITE PLAN



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LRB LAUNCH SITE PLAN SYNOPSIS

TODAY'S FACILITIES

USE AS IS

- BARGE DOCKS
- OPF

MODIFY

- VAB HIGH BAYS
- CRAWLERWAY
- LETF
- LCC
- LAUNCH PAD FAC
- ELEC. PWR. DIST.

ADDITIONAL FACILITIES

- LRB/ET PROCESSING
- MLPs

SUPPORTING DOCUMENTATION

- OMD
- OMI / PM-OMIs

SOFTWARE CHANGES

- RSLS & GLS
- FLIGHT

- ACTIVATION
  - BUDGET
  - AUTHORITY
  - CONTRACTS
  - ENGINEERING
  - PROCUREMENT
  - CONSTRUCTION
  - INSTALLATION
  - VERIFICATION
  - TURN OVER
  - CERTIFICATION

TRANSITION

△ HARDWARE ON DOCK

△ INITIAL LAUNCH CAPABILITY

GRADUATED LAUNCH RATE

3 MISSIONS IN 1996

△ INITIAL OPERATIONAL CAPABILITY

6 MISSIONS IN 1997
9 MISSIONS IN 1998
12 MISSIONS IN 1999
14 MISSIONS IN 2000

△ TRANSITION COMPLETE 14-LRB 0-SRB MISSIONS/YEAR

OPERATIONS

INITIAL GOAL

(MINIMUM SUSTAINED LAUNCH RATE 14/YR)

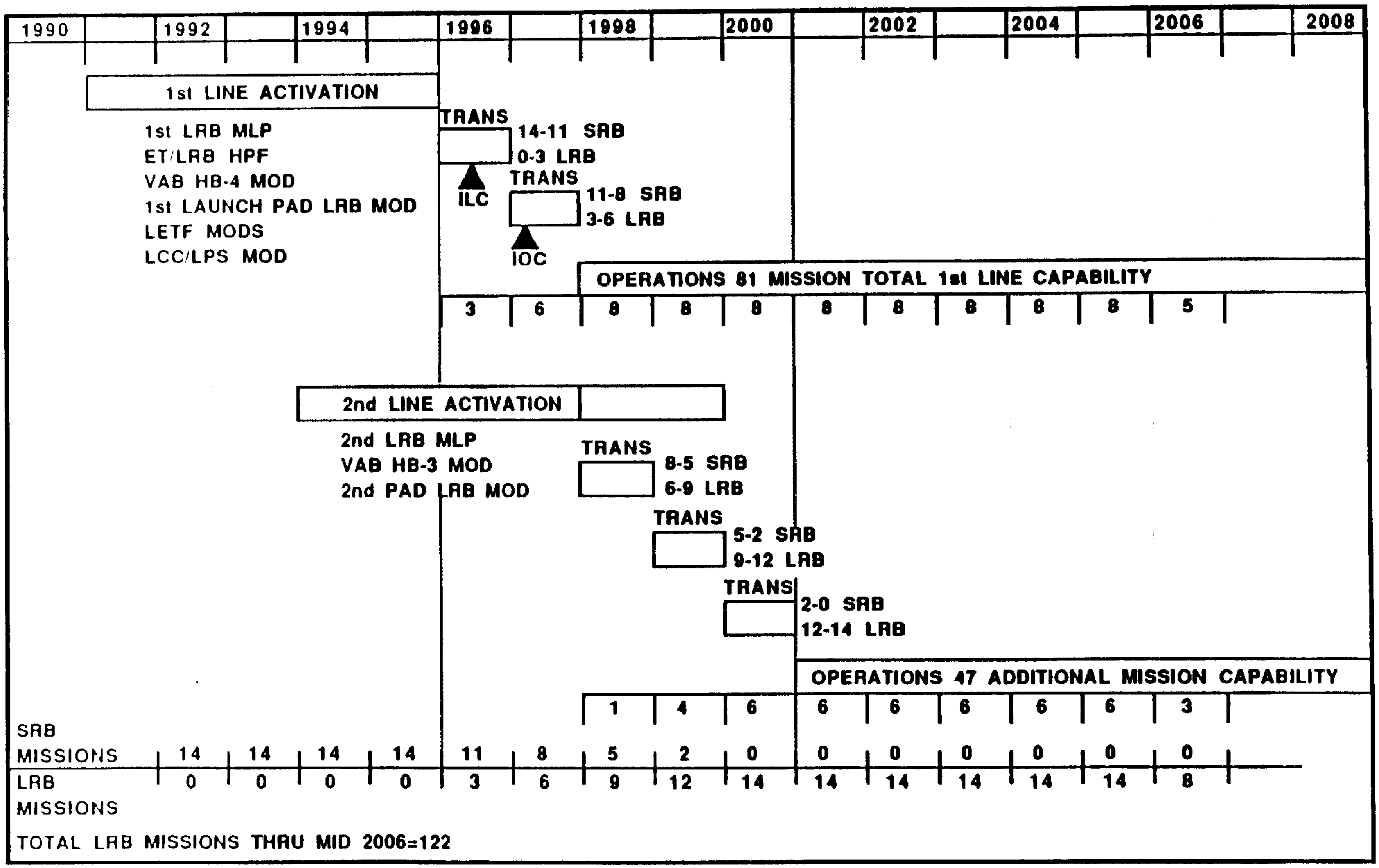
FUTURE POTENTIAL

- SHUTTLE 'C'
- ALS
- STANDALONE

FACILITY TRANSITION OVERVIEW

THIS GRAPH SHOWS THE TWO LINES OF FACILITIES PLANNED AND THE ASSOCIATED PART OF THE TRANSITION FLIGHT RATE COVERED. THE OPERATIONAL CAPABILITY IS ALSO ILLUSTRATED WITH THE FINAL MIX OF STS MISSIONS SUMMARIZED AT THE BOTTOM.

TRANSITION OVERVIEW



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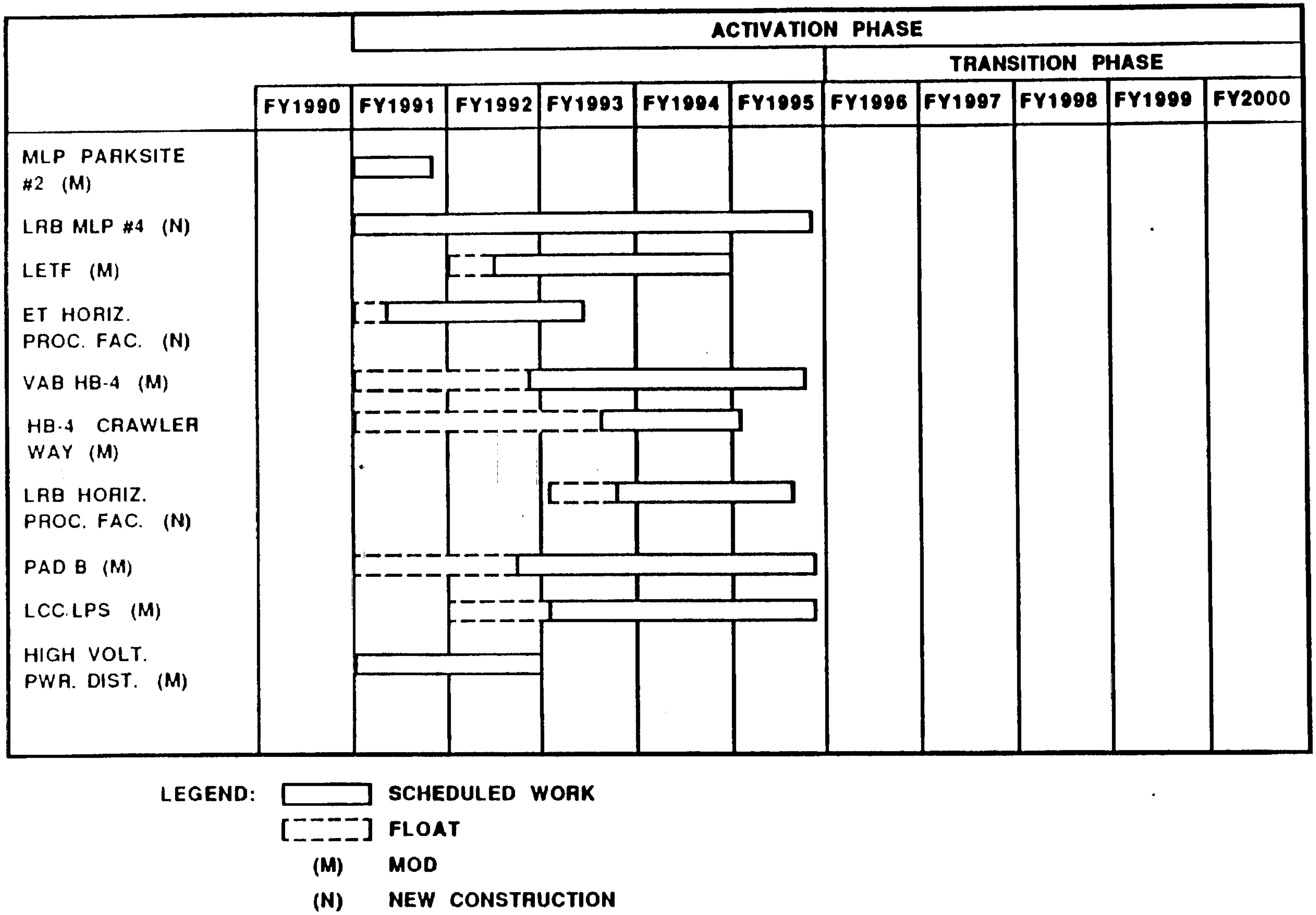
FIRST LINE FACILITY ACTIVATION

THE FIRST LINE FACILITIES ARE IDENTIFIED IN THIS GRAPHIC, AND THE END-TO-END IMPLEMENTATION DURATIONS FOR EACH STATION SET ARE DISPLAYED. THESE FACILITIES ARE REQUIRED TO SUPPORT THE PROPOSED LRB PATHFINDER PROGRAM AND ILC, AND RESULT IN THE CAPABILITY TO SUPPORT LRB FLIGHT RATES OF 6 to 9 MISSIONS PER YEAR.

THE CURRENT LAUNCH SITE CRITICAL PATH IS THE DESIGN, CONSTRUCTION, VERIFICATION AND CERTIFICATION OF THE NEW LRB MLP #4.

CONVERSION OF LC-39 PAD B TO LRB /STS CAPABILITY, POSES THE GREATEST TECHNICAL AND PROGRAMMATIC SCHEDULE RISK IN THE SCOPE OF LRB ACTIVATION AT KSC. DESIGN IS CHALLENGED BY THE CONSTRAINT OF MAINTAINING SRB/STS LAUNCH CAPABILITY. SCHEDULE CHALLENGES ARE ASSOCIATED WITH MAINTAINING THE STS PROGRAM FLIGHT RATE WHILE MODIFYING AN OPERATIONAL LAUNCH PAD.

FIRST LINE FACILITY ACTIVATION



SRB/LRB PROCESSING FACILITY UTILIZATION

THIS GRAPH (ONLY ONE OF TEN YEARS COVERED IN THE FINAL REPORT) SHOWS THE KSC ACTIVATION ACCOMMODATIONS THAT HAD TO BE MADE AS WELL AS THEIR IMPACT ON SRB/LRB FLOW PROCESSING.

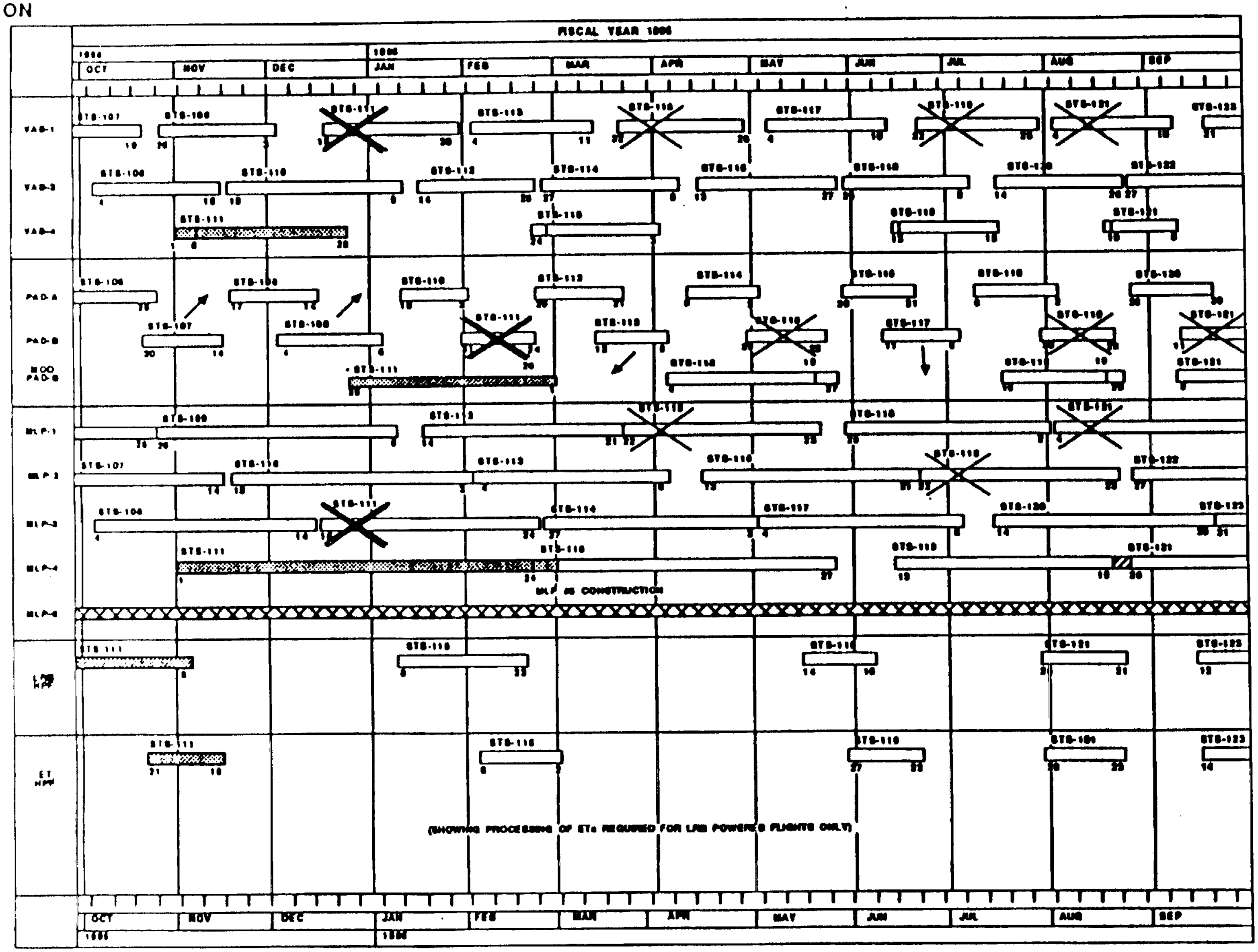
- ALL MISSION PROCESSING FLOWS KEEP THE ORIGINALLY SCHEDULED LAUNCH DATE (LRB FLOWS WERE "BACKED OFF" THIS DATE USING THE NEW FACILITIES AND TIME LINES).
- ARROWS INDICATE PROCESSING ACTIVITIES DISPLACED TO ALTERNATE FACILITIES.
- X's INDICATE FLOW PROCESSING REQUIREMENTS CANCELLED OR SUBSTANTIALLY CHANGED DUE TO CHANGE FROM SRB TO LRB.

KSC ADVANCED PROJECTS & TECHNOLOGY OFFICE

LRBI FINAL ORAL PRESENTATION

SRB / LRB PROCESSING FACILITY UTILIZATION

STS-111 FIRST LRB STACK



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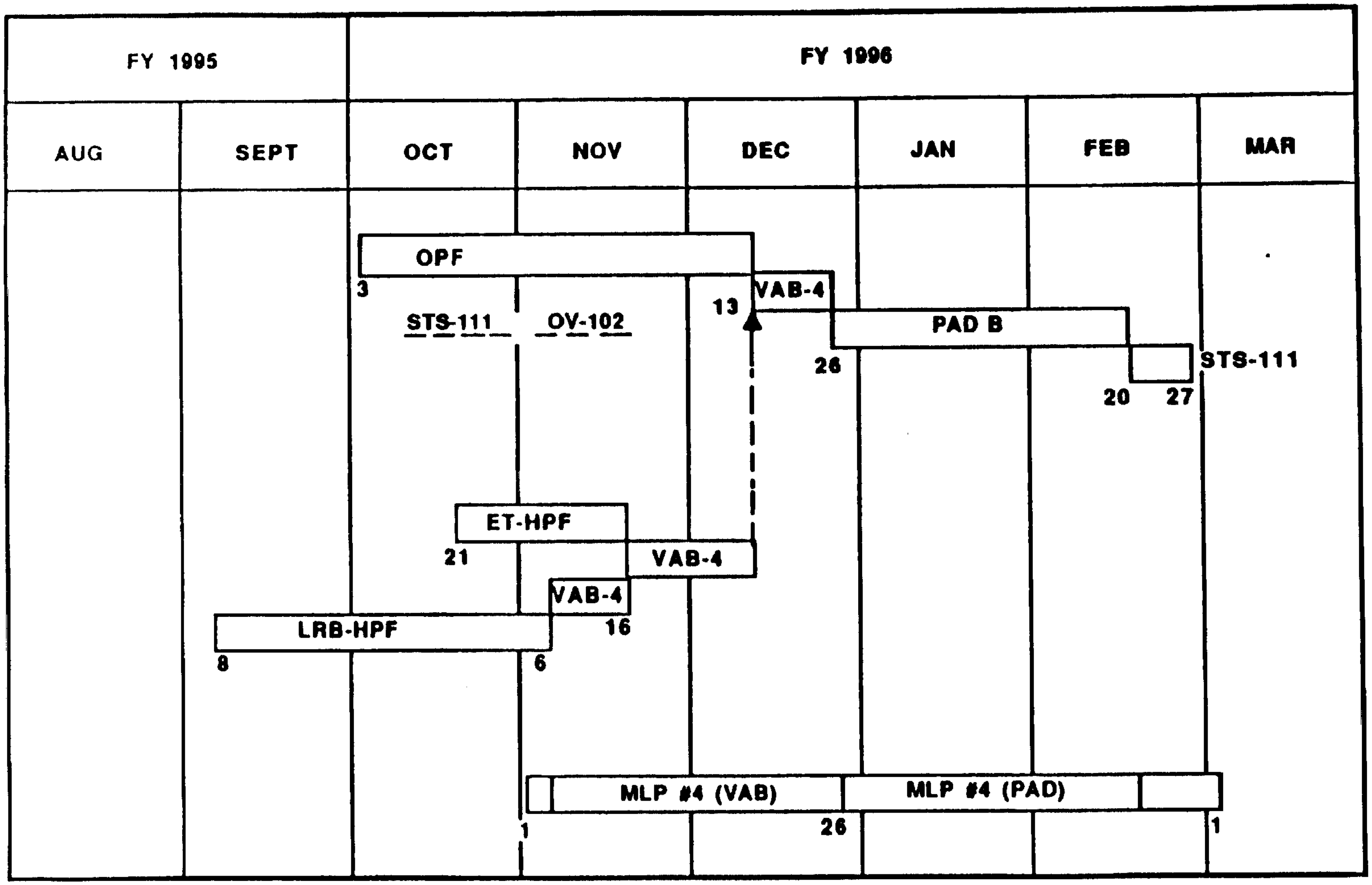
LRB/STS-111-1ST LAUNCH TABLE

FY 1996-I.L.C. FIRST LRB POWERED STS MISSION

KSC LOCATION	PROCESSING FUNCTION	GENERIC WORK DAYS	LOCATION SCHEDULE DAYS/SHIFTS (FACTOR)	CALENDAR START	CALENDAR COMPLETE	CALENDAR DAYS
—	STS-111 MISSION	7	7/3 (1.00)	FEB 20	FEB 27	7
PAD	FINAL C/O & CD	50	6/3 (1.14)	DEC 26	FEB 20	57
VAB	ORB MATE & INTEG TEST	13	7/3 (1.00)	DEC 13	DEC 25	13
OPF	ORBITER PROCESSING	55*	5/3 (1.29)	OCT 03	DEC 12	71
VAB	LRB/ET MATE AND C/O	27	7/3 (1.00)	NOV 16	DEC 12	27
ET-HPF	ET PROCESSING	20*	5/3 (1.29)	OCT 21	NOV 15	26
VAB	LRB MATE TO MLP	10	7/3 (1.00)	NOV 06	NOV 15	10
LRB-HPF	LRB STAND ALONE PROC.	45	5/3 (1.29)	SEP 08	NOV 05	58
MLP	STS INTEGRATION SUPPORT (INCLUDING 5-DAY HOLDDOWN POST VALIDATION)	55	7/3 (1.00)	NOV 01	DEC 25	55
MLP	LAUNCH READINESS (INCLUDING 10 DAYS FOR POST LAUNCH REFURB)	60	6/3 (1.14)	DEC 26	MAR 01	69

* Function not subject to Learning Curve Factor (LCF), All others multiplied by a LCF of 2.5 for this flow only.

LRB/STS-111 FIRST LAUNCH TIMELINES



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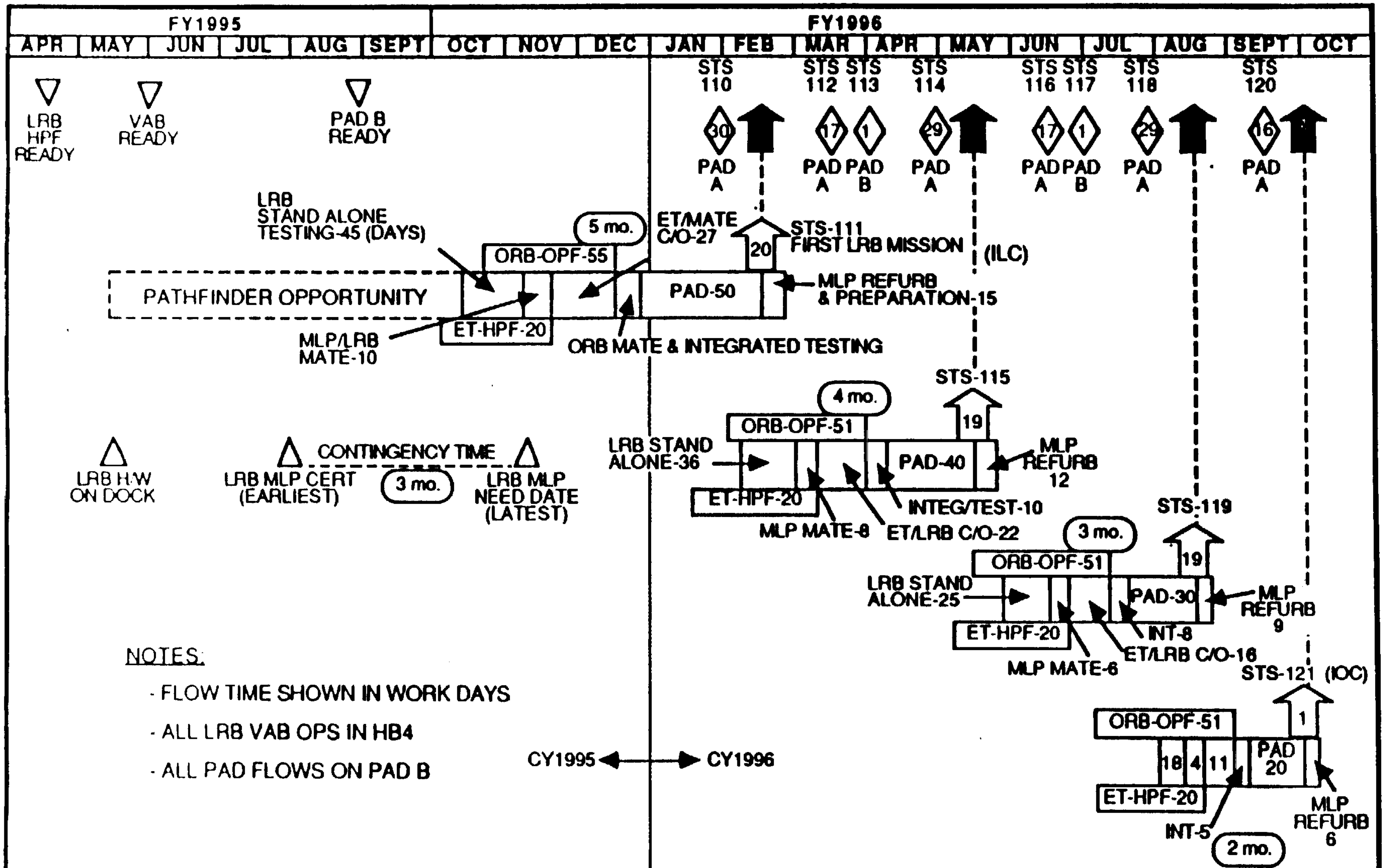
LAUNCH TRA..SITION TO IOC



NOTES:

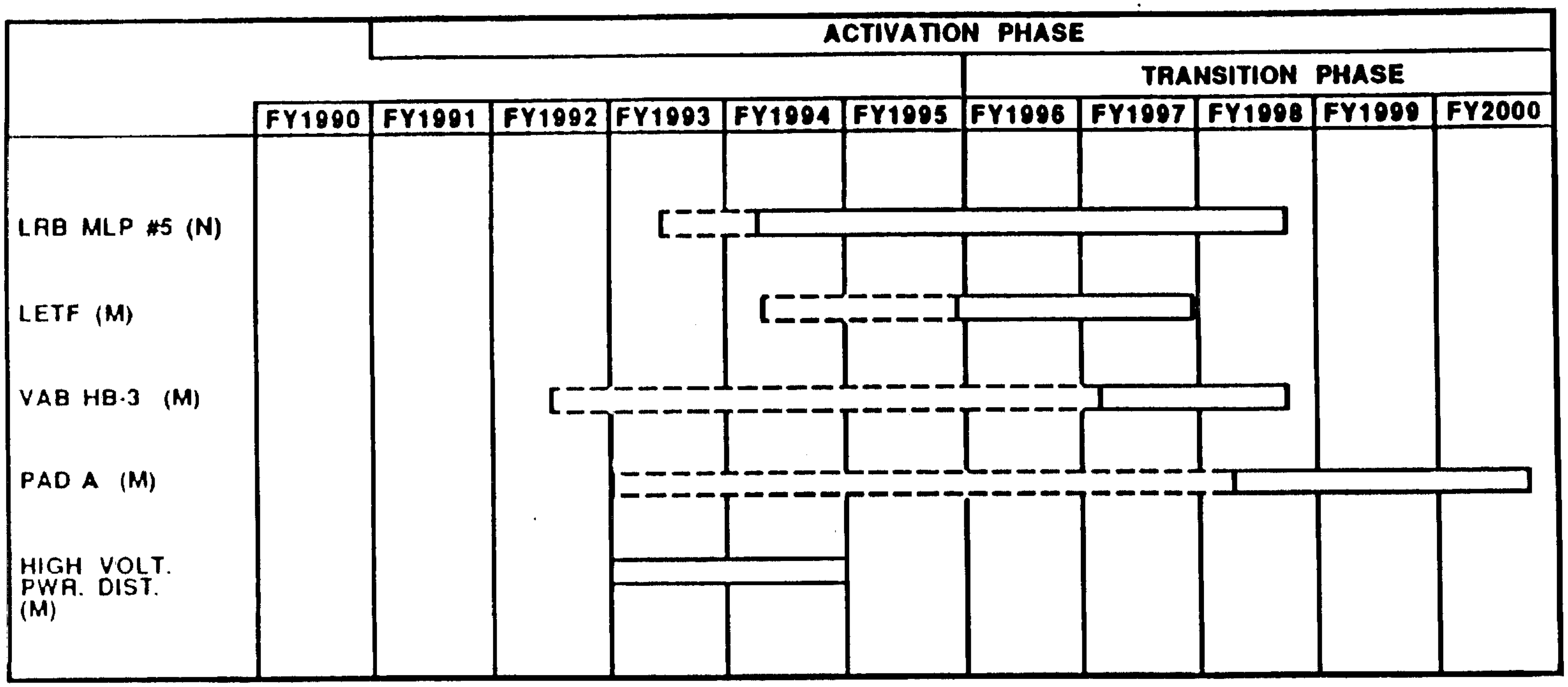
- FLOW TIME SHOWN IN WORK DAYS
- ALL LRB VAB OPS IN HB4
- ALL PAD FLOWS ON PAD B

SECOND LINE FACILITY ACTIVATION

ACTIVATION OF THE SECOND LINE FACILITIES IS REQUIRED TO SUPPORT THE INCREASED LRB FLIGHT RATE, PROJECTED DURING THE THIRD, FOURTH AND FIFTH YEARS OF TRANSITION; CONCLUDING WITH THE CAPABILITY TO SUPPORT 14 LRB MISSIONS PER YEAR DURING THE SUSTAINED OPERATIONAL PHASE.

THE ON-SITE IMPLEMENTATION ACTIVITY FOR THE VAB HIGH BAY 3 AND LC-39 PAD A STATION SETS, ARE SIGNIFICANT SCHEDULING CHALLENGES. MODIFICATION WINDOWS ARE SHORT IN DURATION, FORCING WORK TO PROCEED "AROUND THE CLOCK." CONTINGENCY TIME HAS BEEN ELIMINATED IN THE CONCEPTUAL PROJECT PLANNING.

SECOND LINE FACILITY ACTIVATION



LEGEND: SCHEDULED WORK

FLOAT

(M) MOD

(N) NEW CONSTRUCTION

FACILITY PLANNING CHART

THIS GRAPH IS AN ARTEMIS PRESENTATION OF THE MARCH 1988 MULTI-MISSION MANIFEST. THE LAUNCH RATE PROJECTED FOR THE 1996-2000 TIME PERIOD IS TYPICALLY 14 MISSIONS PER YEAR.

o HIGHLIGHTED MISSIONS WERE CHOSEN FOR CONVERSION FROM SRB's TO LRB's

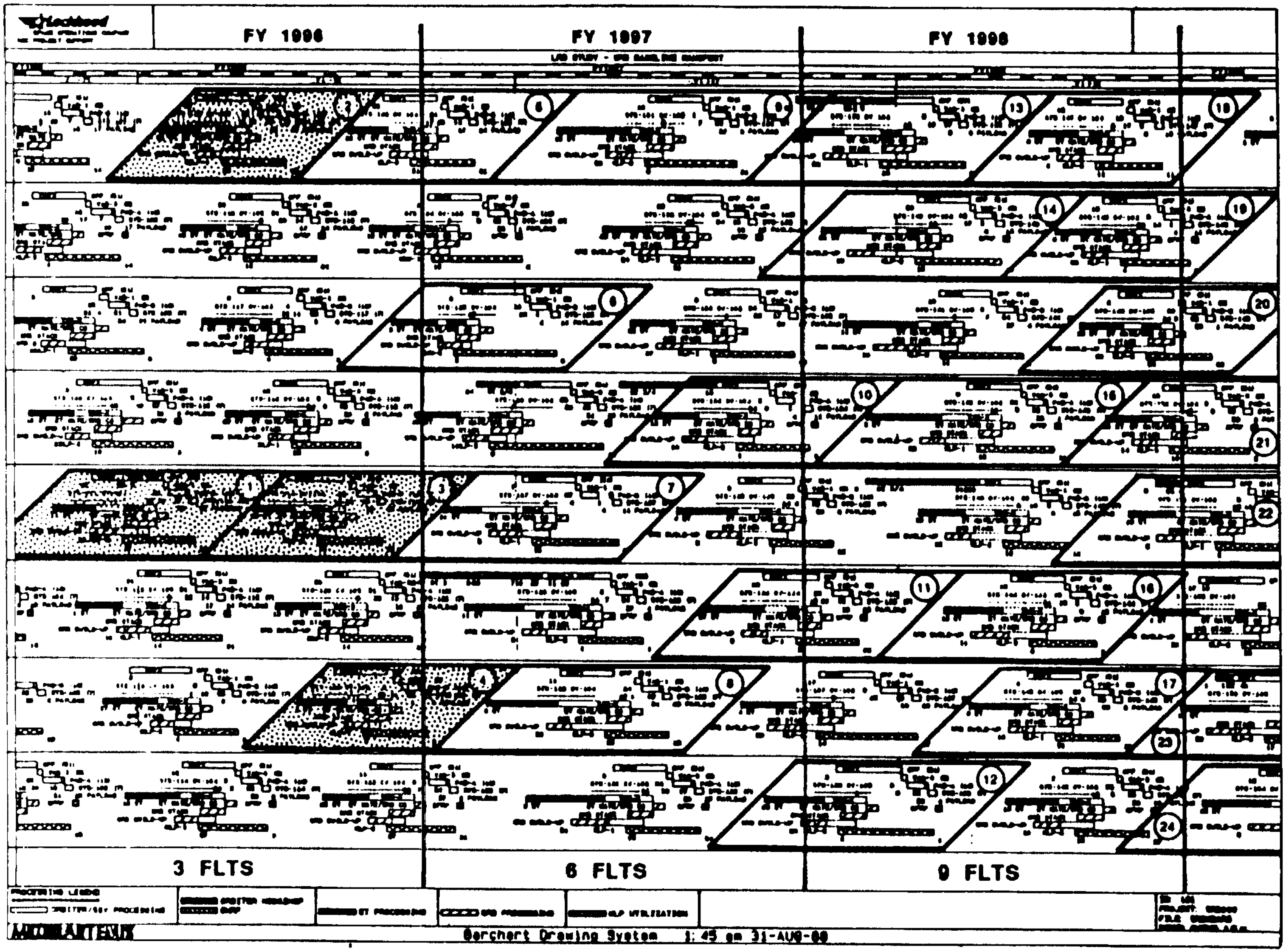
o CIRCLED NUMBER INDICATES LRB MISSION SEQUENCE

  - MISSION (1) EXERCISES THE INITIAL LAUNCH CAPABILITY
  - MISSION (4) ESTABLISHES INITIAL OPERATIONAL CAPABILITY

o FISCAL YEAR DIVISIONS PORTRAY THE 3/6/9/12/14 LRB RAMP RATE

o AFTER THE 44TH MISSION INDICATED IN THE TRANSITION PERIOD, THE SUSTAINED OPERATIONAL PHASE ACCOMPLISHES THE LRB PROGRAM LIFE THROUGH 122 MISSIONS TOTAL IN FY2006.

PROCESSING MANIFEST (1996-1998)



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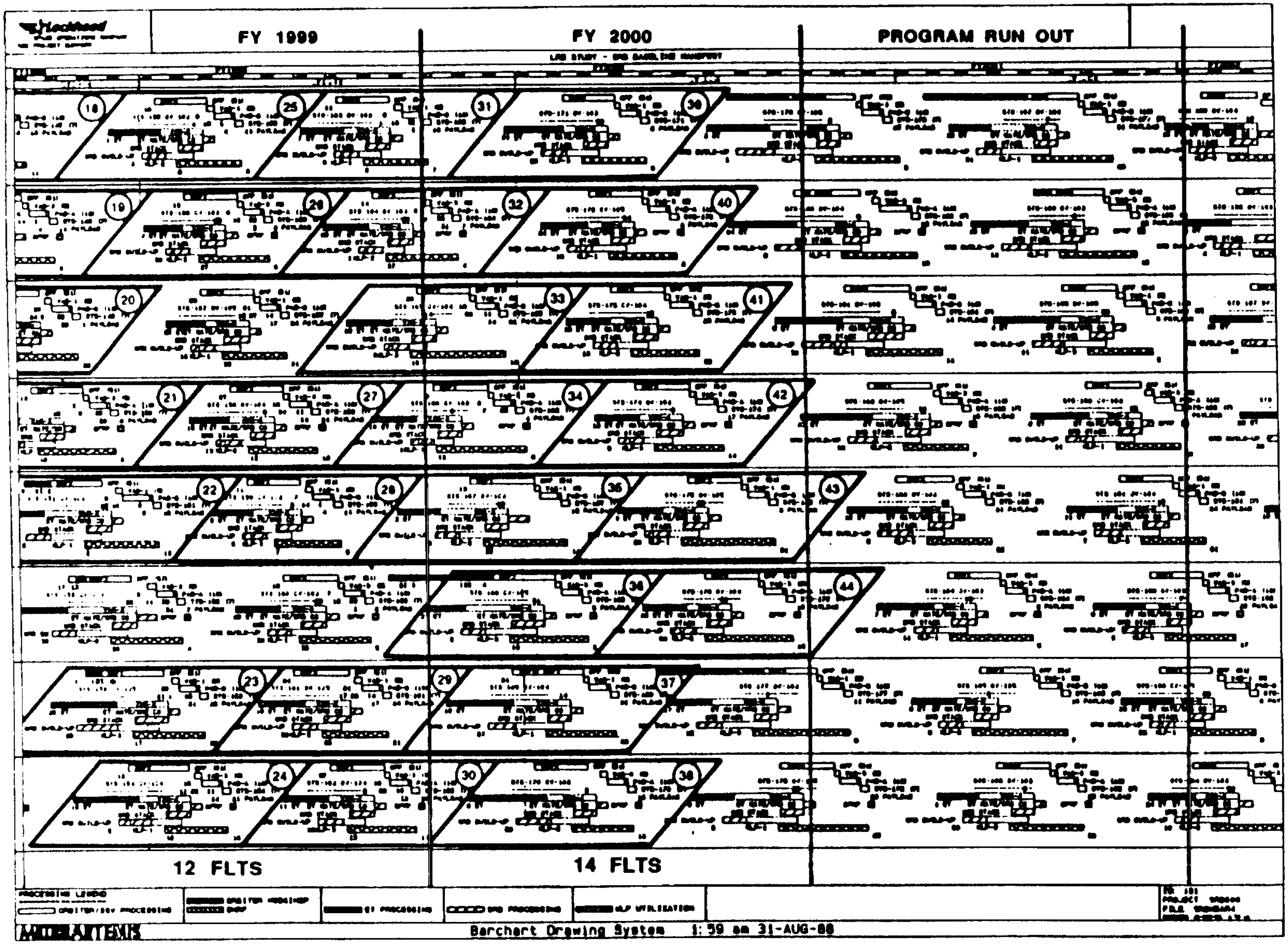
PROCESSING MANIFEST (1999-2000)



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DOCUMENTATION REQUIREMENTS

- FLIGHT HARDWARE DRAWINGS AND LRU SPECIFICATIONS (NEW)
- GSE AND LSE DRAWINGS, FMEA/CIL ANALYSIS, AND PM OMIs (NEW)
- LOGISTICAL SPARES LISTS, AND SPARES AND PROPELLANT ACQUISITION PLANS (NEW)
- OMRSD AND ASSOCIATED PROCESSING OMIs AND JOB CARDS (REVISION)
  - HORIZONTAL ET PROCESSING (REVISION)
  - STAND ALONE HORIZONTAL LRB PROCESSING (NEW)
  - INTEGRATED MATE, TESTING, AND CLOSE OUT - VAB (REVISED)
  - PAD OPERATIONS (REVISION)
- LAUNCH PROCESSING SYSTEM SOFTWARE (NEW)
  - LAUNCH COMMIT CRITERIA (REVISION)
  - FLIGHT RULES (REVISION)
- STANDARD PRACTICE INSTRUCTIONS AND MANUALS (REVISION)

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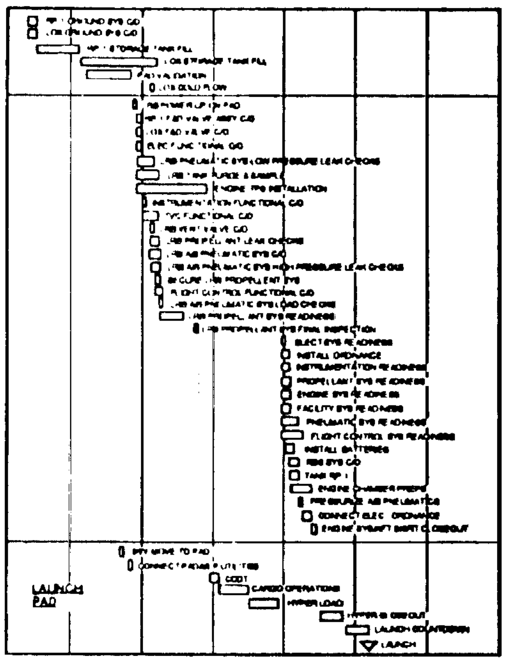
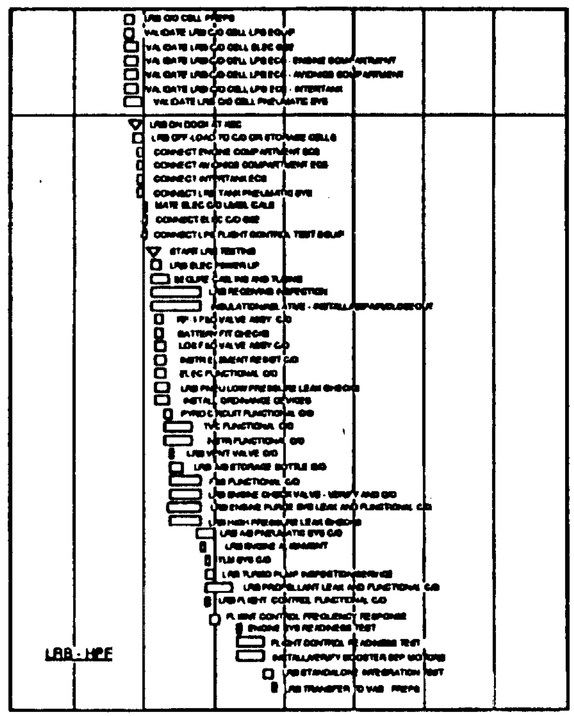
GENERIC LRB FLOW

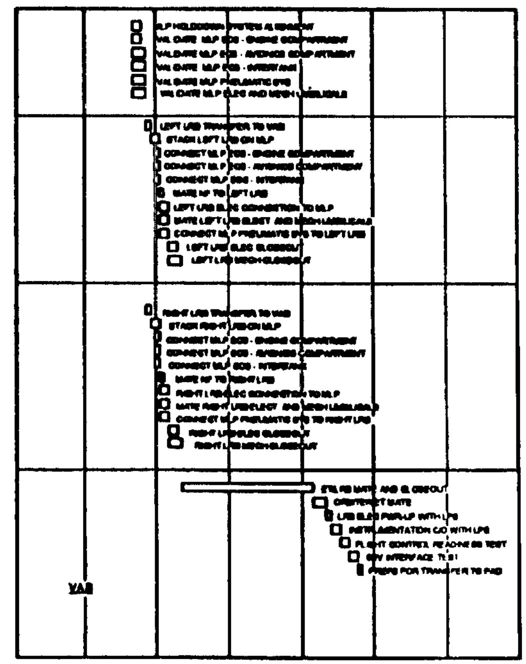
HPF



VAB



PAD



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NASA/CONTRACTOR MANPOWER REQUIREMENTS

THESE MANPOWER REQUIREMENTS ARE THE CUMULATIVE SUPPORT REQUIREMENT FOR THE LRB PROGRAM. THREE TEAMS MAKE UP THE SUPPORT GROUP.

ACTIVATION MANAGEMENT TEAM	- RESPONSIBLE FOR COORDINATION OF DESIGN, CONSTRUCTION AND ACTIVATION OF FACILITIES.
	- INTERFACE BETWEEN THE LRB ACTIVATION AND OPERATION, SRB PROGRAM MIGRATE TO TO LRB TEAM AS CORE GROUP FOR OPERATIONAL PHASE.
NASA ENGINEERING INTERFACE TEAM	- PERFORM ENVIRONMENTAL IMPACT STUDIES FOR NEW FACILITIES AND MODIFICATIONS TO EXISTING FACILITIES.
	- ENGINEERING DOCUMENT - CHANGE AND APPROVAL LOOPS SYSTEM WALK-DOWNS/TEST SURVEILLANCE
	- SCHEDULES AND APPROVALS
	- SITE CONTROL
NASA OPERATIONS INTERFACE TEAM	- OPERATIONS AND ENGINEERING OMD
	- OPERATIONS AND ENGINEERING SOFTWARE
	- OPERATIONS AND ENGINEERING CERTIFICATIONS
	- OPERATIONS AND ENGINEERING ORI's
	- OPERATIONS AND ENGINEERING PATHFINDER
	- OPERATIONS AND ENGINEERING TURNOVER/ACCEPTANCE
	- OPERATIONS AND ENGINEERING CDR's
	- OPERATIONS AND ENGINEERING TRAINING

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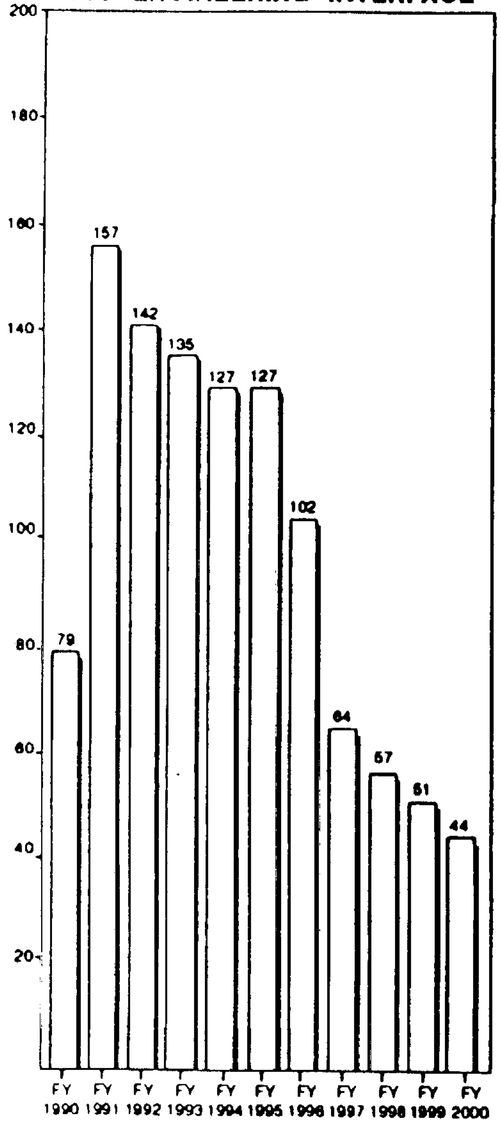
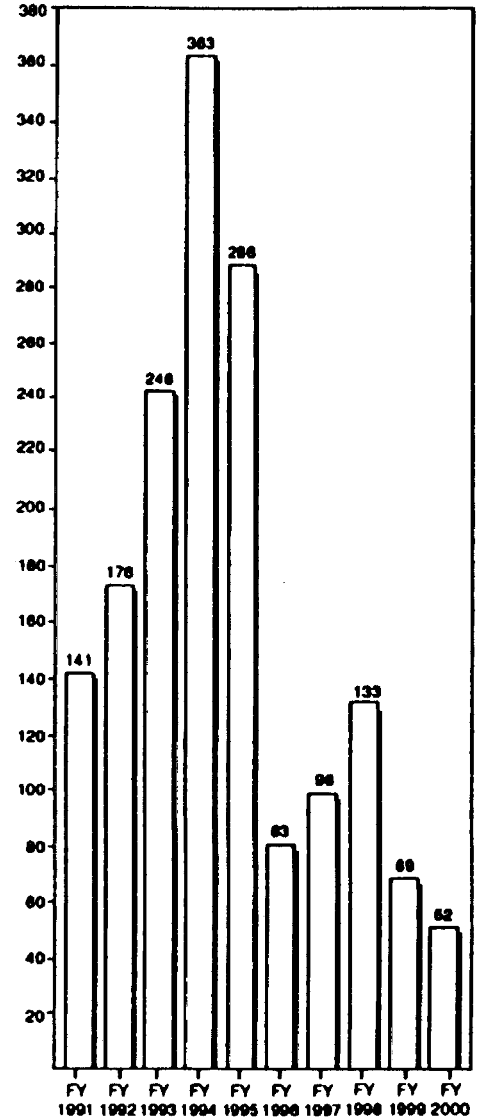
LRBI FINAL ORAL PRESENTATION

ACTIVATION MAN OWER REQUIREMENTS

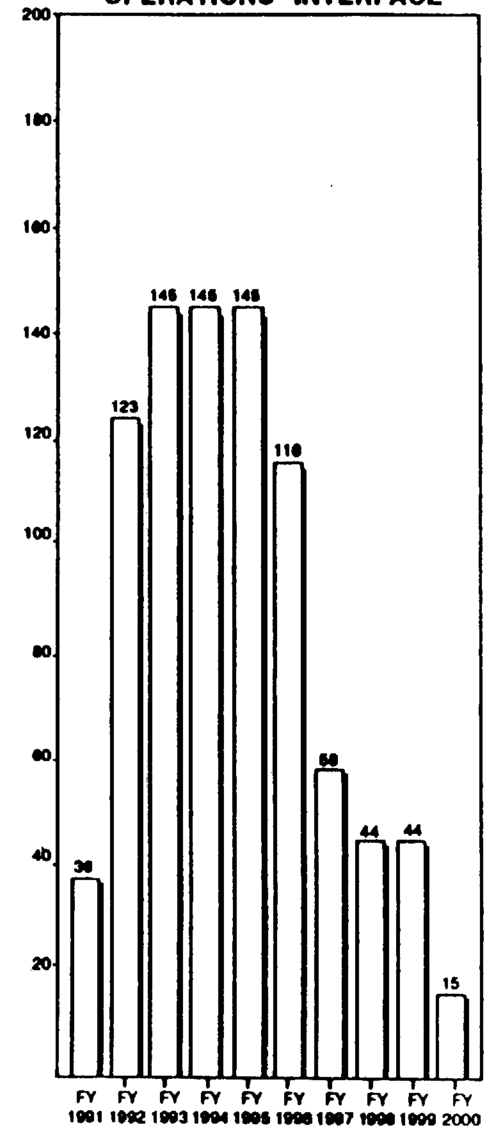
STS ENGINEERING INTERFACE



ACTIVATION TEAM



STS
OPERATIONS INTERFACE



PROCESSING MANPOWER REQUIREMENTS

THE GENERIC ARTEMIS LRB FLOW MODEL CPM WAS RESOURCE LOADED WITH PROJECTED TECHNICIAN HEADCOUNT FOR EACH LRB PROCESSING ACTIVITY. THERE WAS NOT AN ATTEMPT TO LEVEL MANPOWER. PEAKS WERE ALLOWED TO DEVELOP TO MAINTAIN MINIMUM PROCESSING TIME IN EACH FACILITY. CRITICAL PATH ITEMS ARE OUTLINED WITH THE DARK BROAD LINES. PARALLEL TASKS ARE ACCOMPLISHED AT THE EARLIEST START POINT AND COMPLETED AT THE EARLIEST FINISH TIME. THE TECHNICIANS ARE STATIONIZED AT THE FACILITY AND DO NOT MOVE WITH THE BOOSTER. THE GRAPHS ARE BY SHIFT AND MUST BE SUMMED TO DETERMINE PEAK HEADCOUNT. THE PEAK HEADCOUNT BY FACILITY ARE AS FOLLOWS:

HPF = 260 ON THE 4TH DAY

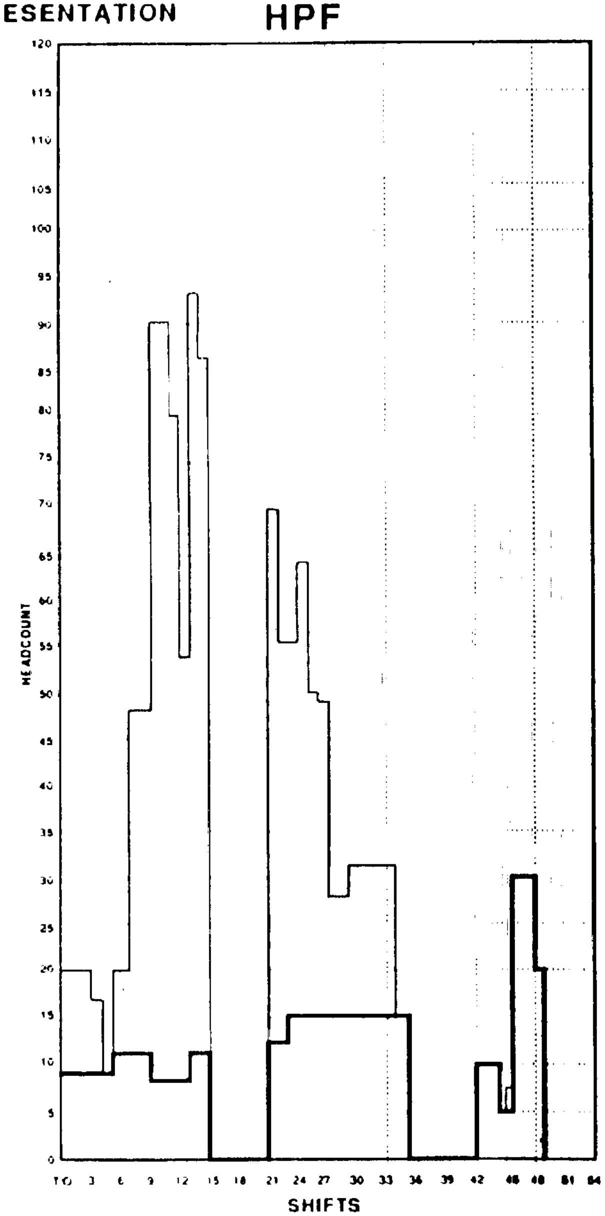
VAB = 70 ON THE 4TH DAY

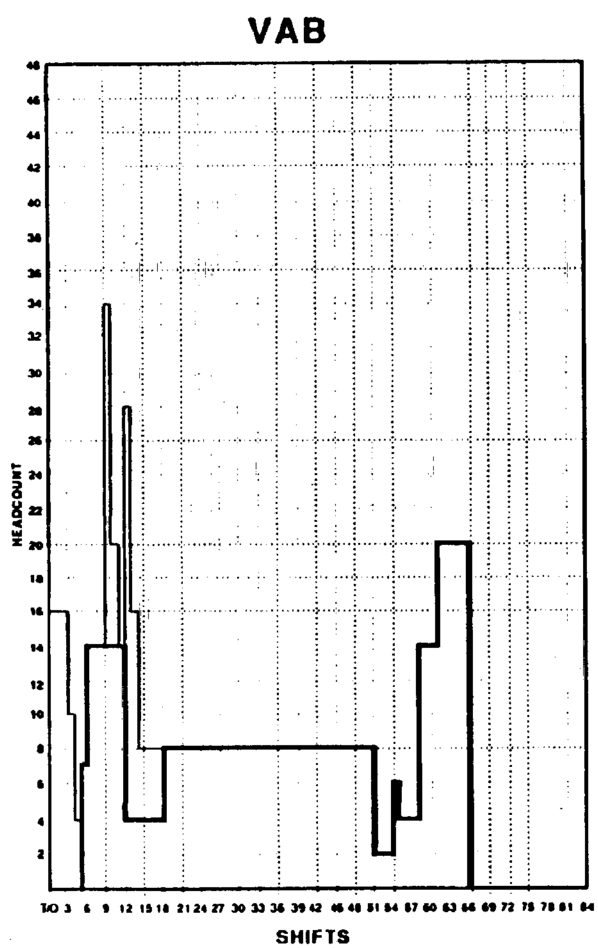
PAD = 107 ON THE 16TH DAY

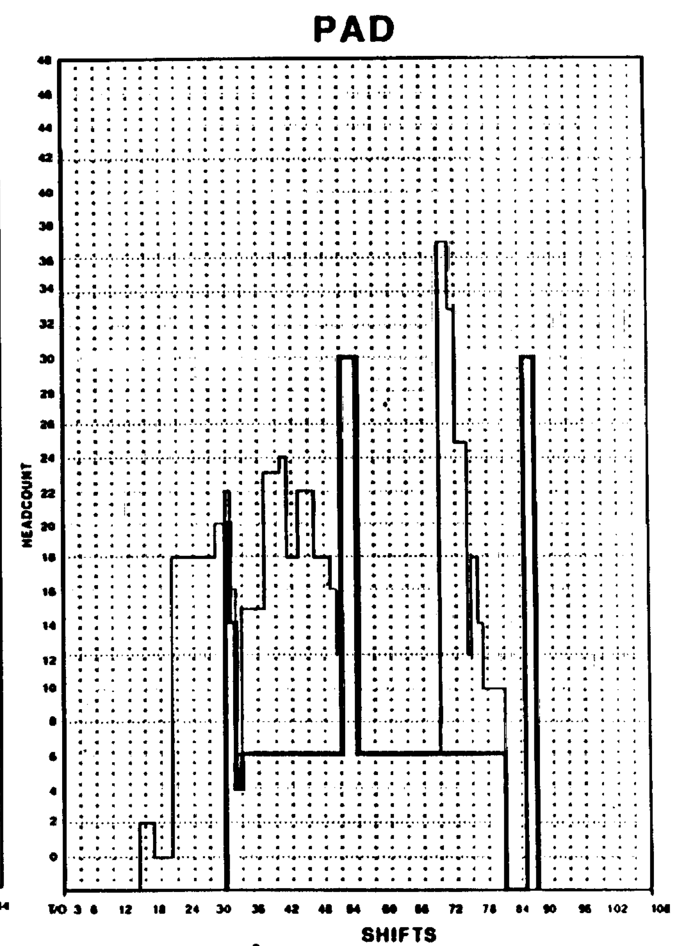
TOTAL = 437

PROCESSING MANPOWER REQUIREMENTS

TECHNICIAN MANLOADING BY LOCATION







— CRITICAL PATH MANLOADING

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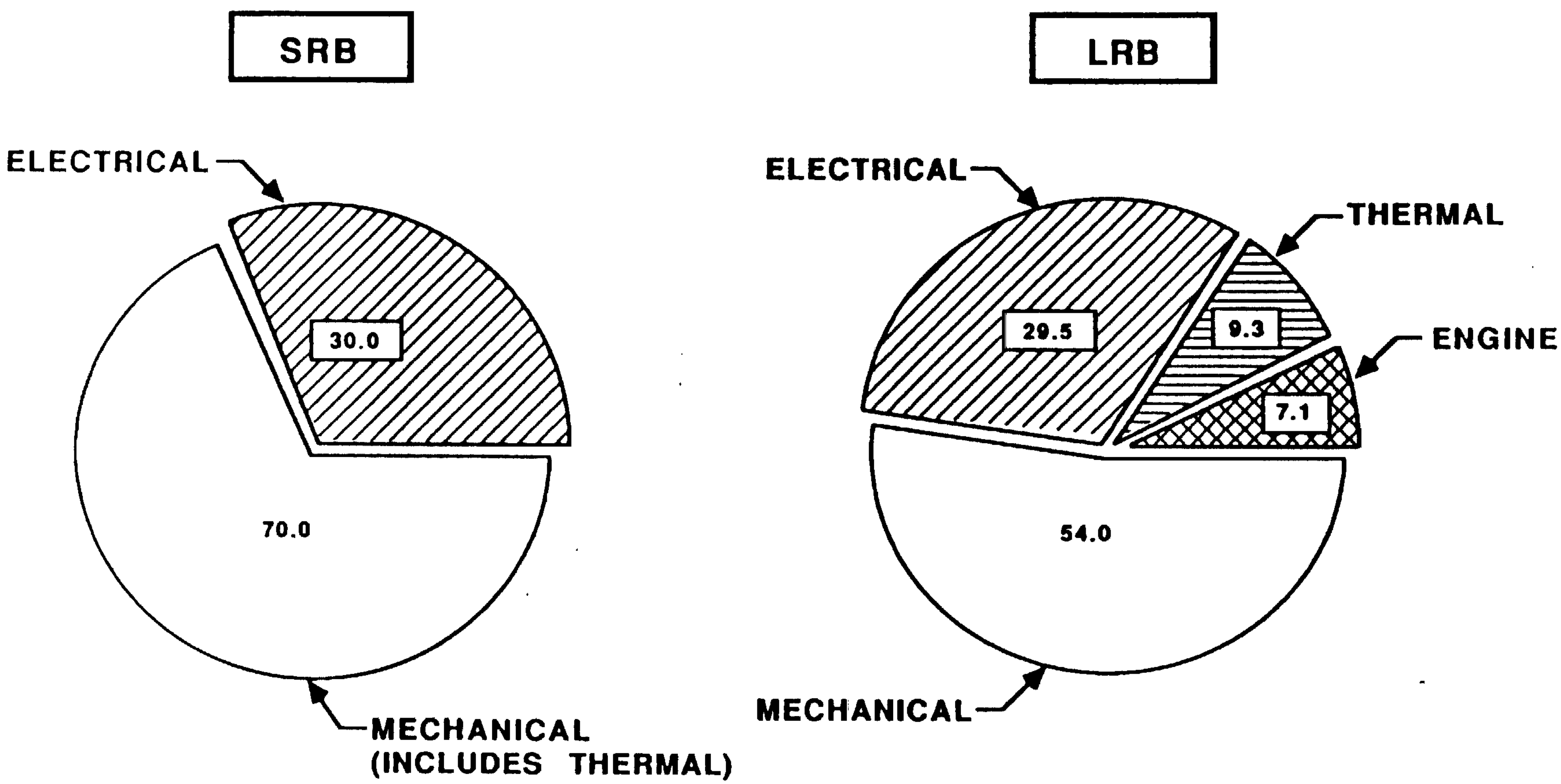
TECHNICAL SKILL MIX

THE PERCENTAGES OF SKILLS REQUIRED FOR LRB GROUND PROCESSING WERE DETERMINED BY AN EXAMINATION OF EACH WORK TASK IN THE ARTEMIS LRB FLOW MODEL. BECAUSE OF THE REQUIREMENT FOR ELECTRICAL TVC/FLIGHT CONTROLS, THERE IS A HIGH PERCENTAGE OF ELECTRICAL SKILLS. ENGINE SKILLS SEEM LOW, BUT THAT IS BASED ON A "SHIP AND SHOOT" CONCEPT AND SCHEDULED TASK. IF THE POTENTIAL FOR UNSCHEDULED WORK IS CONSIDERED BASED ON SSME AND ET PROCESSING, THE PERCENTAGE COULD GO MUCH HIGHER. ANOTHER FACTOR WAS THE PREMISE THAT WORK ON THE TVC ACTUATORS WAS ASSIGNED TO ELECTRICIANS AND ENGINE PLUMBING WAS ASSIGNED TO MECHANICAL TECHNICIANS. IF THESE ASSUMPTIONS WERE REVERSED THE RATIO WOULD INCREASE FOR ENGINE TECHNICIANS. THE PERCENTAGES FOR SRB's IS SHOWN FOR COMPARISON. WHILE IT IS UNUSUAL THAT THE PERCENTAGE FOR ELECTRICAL SKILLS IS THE SAME, IT CAN BE EXPLAINED. MTI CROSS UTILIZES ELECTRICIANS ONE WAY TO MECHANICAL WORK.

TECHNICAL SKILL MIX

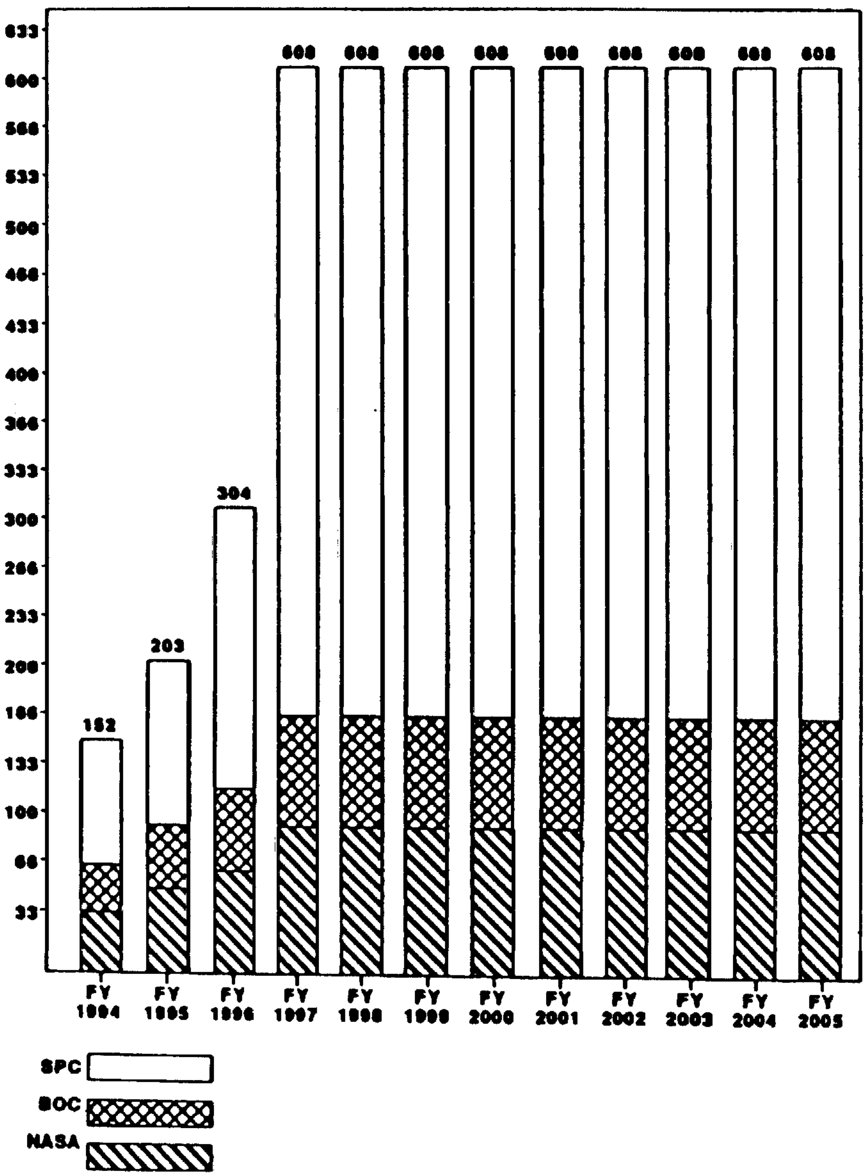


MANPOWER REQUIREMENTS - LRB PROCESSING

HIRING AND TRAINING OF TECHNICIANS AND THE SUPPORT TEAM HAS TO BEGIN IN FY 1994 EVEN THOUGH THE HARDWARE WILL NOT BE AVAILABLE UNTIL MID CY 1995. THIS LEAD TIME IS NECESSARY TO ASSURE THAT TRAINING QUALIFICATIONS/CERTIFICATIONS ARE IN PLACE FOR THE PROCESSING OF THE FIRST LRB. ONLY 25% ARE REQUIRED THE FIRST YEAR BECAUSE THE PROCESSING RATE WILL BE LOWER. THE MANPOWER BUILD-UP INCREASES WITH THE FLIGHT RATE AND PEAKS IN 1997. THE HEADCOUNT WILL REMAIN STABLE UNTIL FY 2006. MANPOWER BEYOND 2006 WILL DEPEND ON FOLLOW-ON PROGRAMS.

MANPOWER COUNTS AND RATIOS WERE DEVELOPED FROM THE BASELINE STUDY WHICH COMPARED SRB/ET/ORBITER MANPOWER AND SUPPORT TO LRB PROCESSING TASKS.

MANPOWER REQUIREMENTS - LRB PROCESSING



TIME PHASED LRB INTEGRATION HEADCOUNT

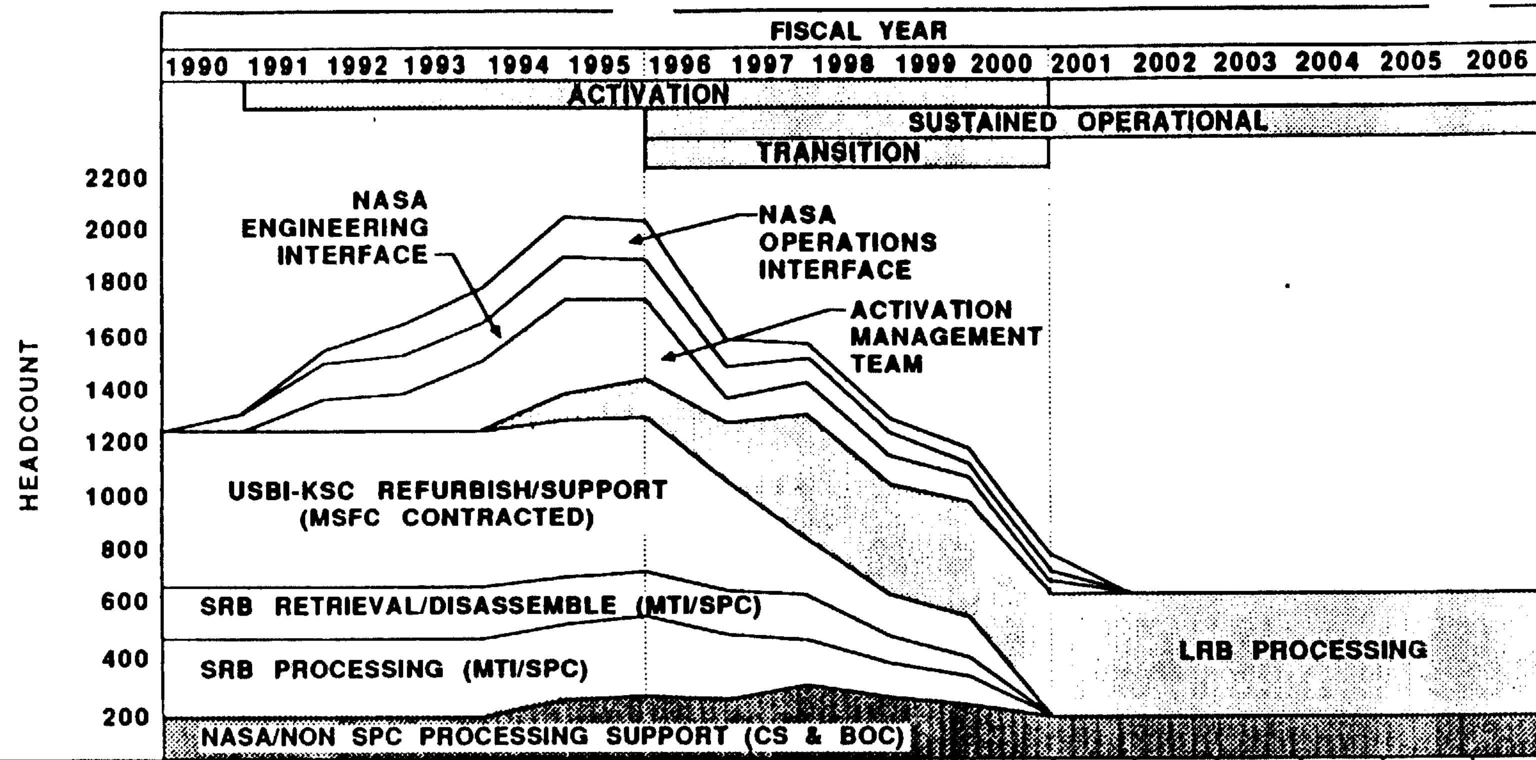
LRB PROCESSING PERSONNEL GRADUALLY REPLACE SRB PROCESSING PERSONNEL. EACH GROUP CONTAINS TECHNICIANS AND THEIR DIRECT SUPPORT FROM ENGINEERING, FACILITY/GROUND SUPPORT, LOGISTICS, QUALITY, SAFETY, OPERATIONS PLANNING AND CONTROL, OVERHEAD AND LPS.

THE NASA/NON SPEC PROCESSING SUPPORT (CS & BOC) PERSONNEL PROVIDE DIRECT SUPPORT TO BOTH SRB AND LRB PROCESSING ACTIVITIES.

THE USBI-KSC REFURBISHMENT/SUPPORT AND SRB RETRIEVAL/DISASSEMBLY PERSONNEL PHASE OUT WITH SRB LAUNCH PHASE OUT.

THE ACTIVATION MANAGEMENT TEAM SUPPORTS THE FACILITY PREPARATIONS.

THE NASA ENGINEERING INTERFACE AND NASA OPERATIONS INTERFACE PERSONNEL SUPPORT THE INTENSIVE ACTIVITIES OF ALL LRB INTERFACE AREAS IN PREPARATION FOR SUSTAINED OPERATIONAL CAPABILITY.



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
TOTAL	1342	1597	1704	1789	2050	2024	1603	1546	1295	1145	719	608	608	608	608	608	608
NASA OPERATIONS INTERFACE		36	123	145	145	145	116	58	44	44	15						
NASA ENGINEERING INTERFACE	79	157	142	135	127	127	102	64	57	51	44						
ACTIVATION MGMT. TEAM		141	176	246	363	286	83	96	133	69	52						
LRB PROCESSING					110	147	221	441	441	441	441	441	441	441	441	441	441
USBI REFURB/SUPPORT	600	600	600	600	600	600	474	342	216	200							
SRB RETRIEVAL/DISASSEM.	160	160	160	160	160	160	126	91	57	50							
SRB PROCESSING	336	336	336	336	336	336	264	192	120	100							
NASA/NON-SPC PROC. SUPP.	167	167	167	167	209	223	217	262	227	190	167	167	167	167	167	167	167

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LRBI FINAL ORAL PRESENTATION

LRB PROGRAM OPERATING PLAN

LO2/RP-1 PUMP-FED BOOSTERS

FY	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
	FACILITY ACTIVATION															
PROGRAM PHASES						OPERATIONAL										
						TRANSITION										
RECURRING																
PROCESSING				5.50	7.35	11.05	22.05	22.05	22.05	22.05	22.05	22.05	22.05	22.05	22.05	22.05
SPC/BOC/SUPT	8.35	8.35	8.35	10.45	11.15	10.85	13.10	11.35	9.50	8.35	8.35	8.35	8.35	8.35	8.35	8.35
COMMODITIES					.49	1.47	2.94	4.41	5.88	6.86	6.86	6.86	6.86	6.86	6.86	3.92
SPARES/MAT'L			1.09	2.49	21.33	21.33	22.73	27.81	27.81	33.47	33.47	33.47	33.47	33.47	16.73	8.37
SUB TOTAL	8.35	8.35	9.44	18.44	40.32	44.70	60.82	65.62	65.24	70.73	70.73	70.73	70.73	70.73	53.99	42.69
NON-RECURRING																
1ST LINE FAC	52.62	65.53	88.95	112.08	78.56											
2ND LINE FAC			3.05	23.17	27.46	31.11	36.32	49.26	25.63	19.22						
ACTIVATION MGMT TEAM	7.90	9.86	13.78	20.33	16.02	4.65	5.38	7.45	3.86	2.91						
SUB TOTAL	60.52	75.39	105.78	155.58	122.04	35.76	41.70	56.71	29.49	22.13						
TOTALS	68.87	83.74	115.22	174.02	162.36	80.46	102.52	122.33	94.73	92.86	70.73	70.73	70.73	70.73	53.99	42.69

* NUMBERS ARE '87$M

81012-01AH-V/G
/CK1

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SLC-6 CONVERSION TO LRB

DETAILED STUDIES OF VLS RE-ACTIVATION FROM THE PLANNED MOTHBALL STATUS HAVE NOT BEEN PERFORMED. FOR THE PURPOSE OF THIS ASSESSMENT THE VLS STUDIES FOR RE-ACTIVATION FROM MINIMUM FACILITY CARETAKER STATUS WERE MODIFIED TO ACCOUNT FOR ADDITIONAL STAFFING TIME REQUIRED AND INCREASED FACILITY RESTORATION TIME. THE ENGINEERING ASSESSMENT OF THE VLS MODIFICATIONS REQUIRED TO CONVERT TO LRB OPERATION SHOWS THAT THE EFFORT CAN BE COMPLETED PRIOR TO THE INITIATION OF THE RE-ACTIVATION GSTS AND FLOW TESTS. IT IS ANTICIPATED THAT THE LRB CONVERSION SCHEDULE WILL BE PACED BY THE PROCUREMENT AND INSTALLATION OF THE NEW CRYOGENIC DEWAR(S).

AS A RESULT OF THE VLS CURSORY REVIEW, TWO RECOMMENDATIONS HAVE BEEN RECEIVED FROM OUR VLS TEAM, WHICH PROVIDE SOME INTERESTING PROGRAM OPPORTUNITIES.

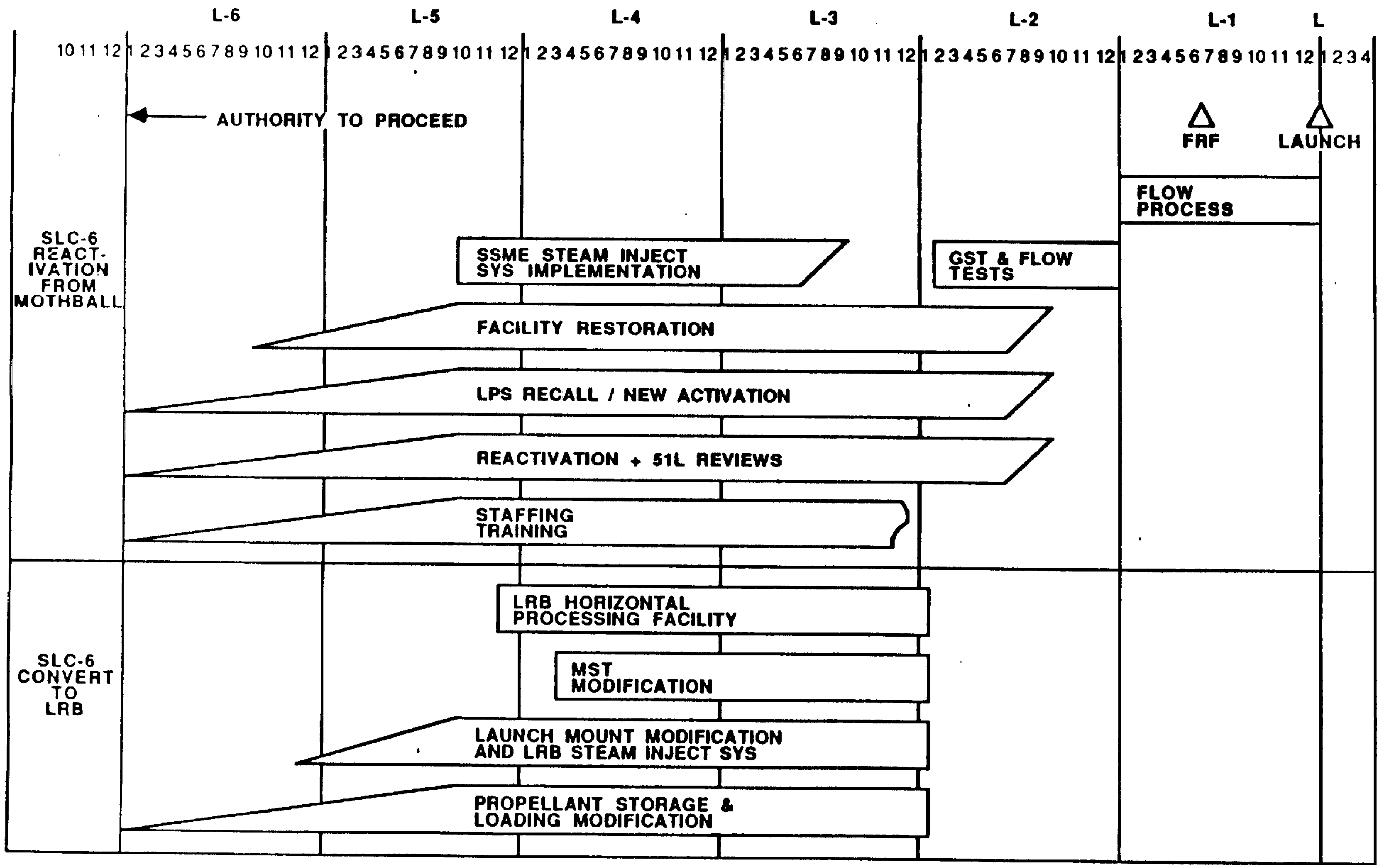
1.) CONSIDER USING VLS TO PATHFIND THE LRB IMPLEMENTATION INTO THE SHUTTLE PROGRAM

- PROCESSING DEVELOPMENT WOULD BE ACHIEVED WITHOUT ANY IMPACT WITH KSC SRB SHUTTLE LAUNCHES
- INTEGRATION OF A DEVELOPED SYSTEM AT KSC WOULD BE LOW TECHNICAL AND SCHEDULE RISK

2.) VLS SHOULD BE CONSIDERED AS THE LRB VEHICLE DEVELOPMENT STATIC HOT FIRING TEST FACILITY

- REQUIRED MODIFICATION COULD BE COST EFFECTIVE
- TESTING WOULD NOT INTERFERE WITH OTHER SHUTTLE FACILITIES

SLC-6 CONVERSION TO LRB



LIQUID ROCKET BOOSTER INTEGRATION

AGENDA

I. INTRODUCTION	Gordon Artley
II. LRBI RESULTS	
BASELINE / LAUNCH SITE SCENARIO	Pat Scott
FACILITIES AND GROUND SYSTEMS	Greg DeBlasio
IMPLEMENTATION	Gordon Artley
COST	Jerry Lefebvre
III. SUMMARY	Gordon Artley

LRBI CONCLUSIONS

KSC CAN ACHIEVE 10 YEARS OF GROUND SYSTEM AND FACILITY ACTIVATION FOR LRB BY 2000. IN ADDITION, 122 LAUNCHES CAN BE ACCOMMODATED FROM 1996 TO 2006. THESE MILESTONES INCLUDE A 5 YEAR, 44 LAUNCH TRANSITION PHASE (SRB-TO-LRB) FOR STS OPERATIONS FROM 1996 TO 2006.

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THE PROPELLANT OPTIONS AND THE BOOSTER CONFIGURATIONS DO NOT IMPOSE NEW HAZARDS OR TECHNOLOGY TO THE KSC SAFETY AND ENVIRONMENTAL COMMUNITY.

THE TRANSITION OF THE SHUTTLE PROGRAM TO LIQUID ROCKET BOOSTER CONFIGURATION GENERATES A PROGRAM LIFE CYCLE COST IN EXCESS OF $15 BILLION. THE OPERATIONS COST WILL BE LESS THAN 10 PERCENT OF THIS LIFE CYCLE COST.

- WE CAN ACHIEVE THE 1990 - 2006 LRB INTEGRATION SCENARIO

- THE PRINCIPAL RISK IS THAT THE LRBI ACTIVATION AND OPERATIONS IMPLEMENTATION MAY IMPACT THE 14 FLIGHTS/YEAR PROGRAM

- WE CAN ACCOMMODATE THE ENVIRONMENTAL AND SAFETY IMPLICATIONS WITH ESTABLISHED KSC POLICIES

- THE LIFE CYCLE COSTS AT KSC WILL BE LESS THAN 10% OF THE TOTAL LRB PROGRAM COSTS. THE KSC NON-RECURRING COST WILL BE LESS THAN 6%

MAJOR PROGRAM RISKS

THE SRB BASELINE MANIFEST THROUGHOUT THE 1990's ASSUMES 14 LAUNCHES PER YEAR, ALTERNATIVELY USING PADS A AND B. THIS PROVIDES LESS THAN 6 WEEKS FOR MAINTENANCE, REFURBISHMENT AND RECERTIFICATION BETWEEN LAUNCHES AT EACH PAD. THE INTENT IS TO LAUNCH CONSECUTIVELY FROM ONE PAD WHILE EXTENDED REFURBISHMENT OR MODIFICATIONS IS REQUIRED AT THE OTHER. THIS SINGLE PAD APPROACH CANNOT BE SUSTAINED FOR AN EXTENDED PERIOD. THE LRB MODIFICATION ACTIVITY MAY REQUIRE MORE THAN 6 MONTHS OF DEDICATED ACCESS TO THE PAD. THIS REPRESENTS A SIGNIFICANT RISK TO ON-GOING LAUNCH OPERATIONS. THE INCREASED FLAME-HOLE SIZE IN THE MLP CREATES A COMPLEX STRUCTURAL DESIGN CONCEPT. THE DESIGN SOLUTION, AS WELL AS THE NON-AVAILABILITY OF THE PRESENT 3 MOBILE LAUNCHERS, DRIVES THE BASELINE OF THE LRB TO PROVIDE NEW MLPS. THIS REQUIRES, IN ADDITION TO THE NEW LAUNCH PLATFORM, A COMPLETE SET OF STS GSE AND GROUND SYSTEMS. THE SCHEDULE FOR IMPLEMENTATION MUST INCLUDE AN EXTENSIVE UTILIZATION OF THE LETF FOR CERTIFICATION OF TWO COMPLETE SETS OF GSE/LSE.

CRITICAL GROUND SYSTEMS RISKS

PAD A & B

- ACCESS TO EXISTING FACILITIES FOR LRB ACTIVATIONS
- FLAME TRENCH AND DEFLECTOR DESIGNS

MLP

- SCHEDULE CRITICAL PATH
- FLAME HOLES AND HOLDDOWN STRUCTURAL DESIGN

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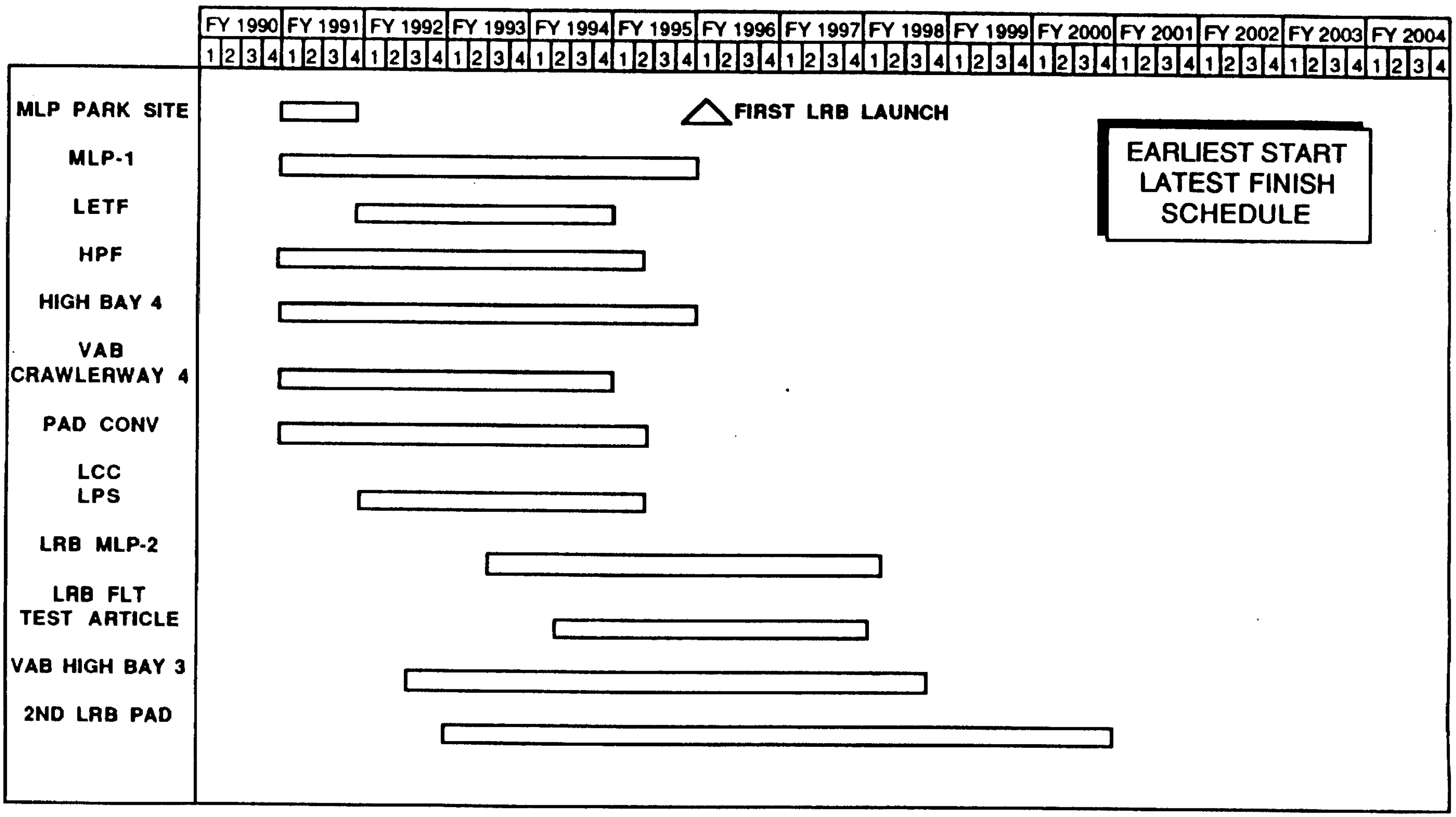

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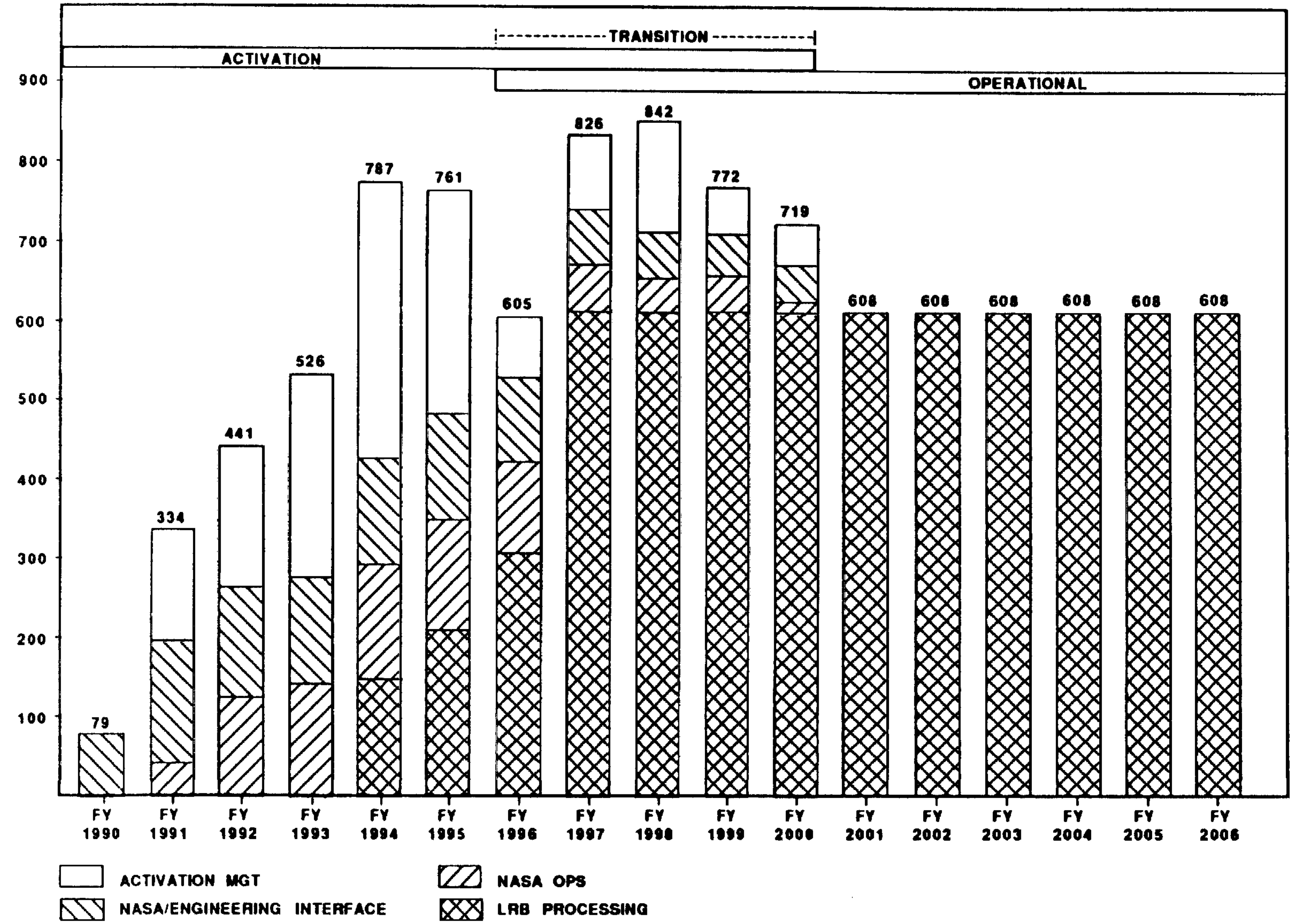
KSC ADVANCED PROJECTS & TECHNOLOGY OFFICE

LRBI FINAL ORAL PRESENTATION

CUMULATIVE LRB MANPOWER



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RECOMMENDATIONS FOR FOLLOW-ON STUDY

THE LRBI STUDY HAS IDENTIFIED A NUMBER OF ISSUES THAT WILL REQUIRE FURTHER STUDY AND IN-DEPTH ANALYSIS. WE SHOULD CONTINUE TO SUPPORT THESE CRITICAL ISSUES WITH THE DEVELOPMENT OF MORE RIGOROUS STUDY TOOLS AND MORE COMPLETE DATABASES. ADDITIONAL INFORMATION, AS IT BECOMES AVAILABLE FROM MSFC, WILL REQUIRE KSC LAUNCH OPERATIONS IMPACT ASSESSMENT. FOR INSTANCE, BOOSTER IMPACTS TO THE PAD WILL REQUIRE FURTHER DESIGN ANALYSIS. THE RESOLUTION OF THESE PROBLEMS WILL REQUIRE FURTHER SUPPORT AND COOPERATION WITH THE MSFC WORKING GROUP.

WE ALSO NEED BETTER TECHNIQUES TO PROVIDE IMPROVED ACCURACY IN DEVELOPING MIXED-MISSION SCHEDULES AND COST. THESE TECHNIQUES MIGHT INCLUDE ENHANCED VERSIONS OF THE ARTEMIS-BASED SRB/STS GROUND PROCESSING FLOW MODEL AND AUGMENTED EDITIONS OF THE GROUND OPERATIONS COST MODEL (GOCM). THE EXPANSION OF GOCM WOULD ALLOW MORE REFINED COST PROJECTIONS THAN CURRENTLY AVAILABLE WITH THE PRESENT PARAMETRIC MODEL.

WE SHOULD ALSO ASSESS ALTERNATIVE LAUNCH SITE CONFIGURATIONS AND SCENARIOS. WE CURRENTLY PLAN TO INTEGRATE THE LRB INTO ON-GOING KSC OPERATIONS. THIS ESTABLISHES A FORMIDABLE CONSTRAINT IN LRB GROUND OPERATIONS PLANNING. THUS, WE MUST EVALUATE A WIDE VARIETY OF LAUNCH SITE CONFIGURATIONS AND SCENARIOS IN ORDER TO FIND AND SELECT THE BEST ALTERNATIVES. THIS INFORMATION WILL BE VALUABLE NOT ONLY TO THE LRB EFFORT, BUT ALSO TO THE LRB-DERIVED PROGRAMS, SUCH AS UNMANNED SHUTTLES OR ALS.

RECOMMENDATIONS FOR FOLLOW-ON STUDY

- CONTINUE TO SUPPORT MSFC WORKING GROUP
- ENHANCE THE LRBI EVALUATION TECHNIQUES FOR MULTI-MISSION ASSESSMENT
- ASSESS ALTERNATIVE LAUNCH SITE CONFIGURATIONS AND SCENARIOS

LIQUID ROCKET BOOSTER INTEGRATION

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LRBI CONCLUSIONS

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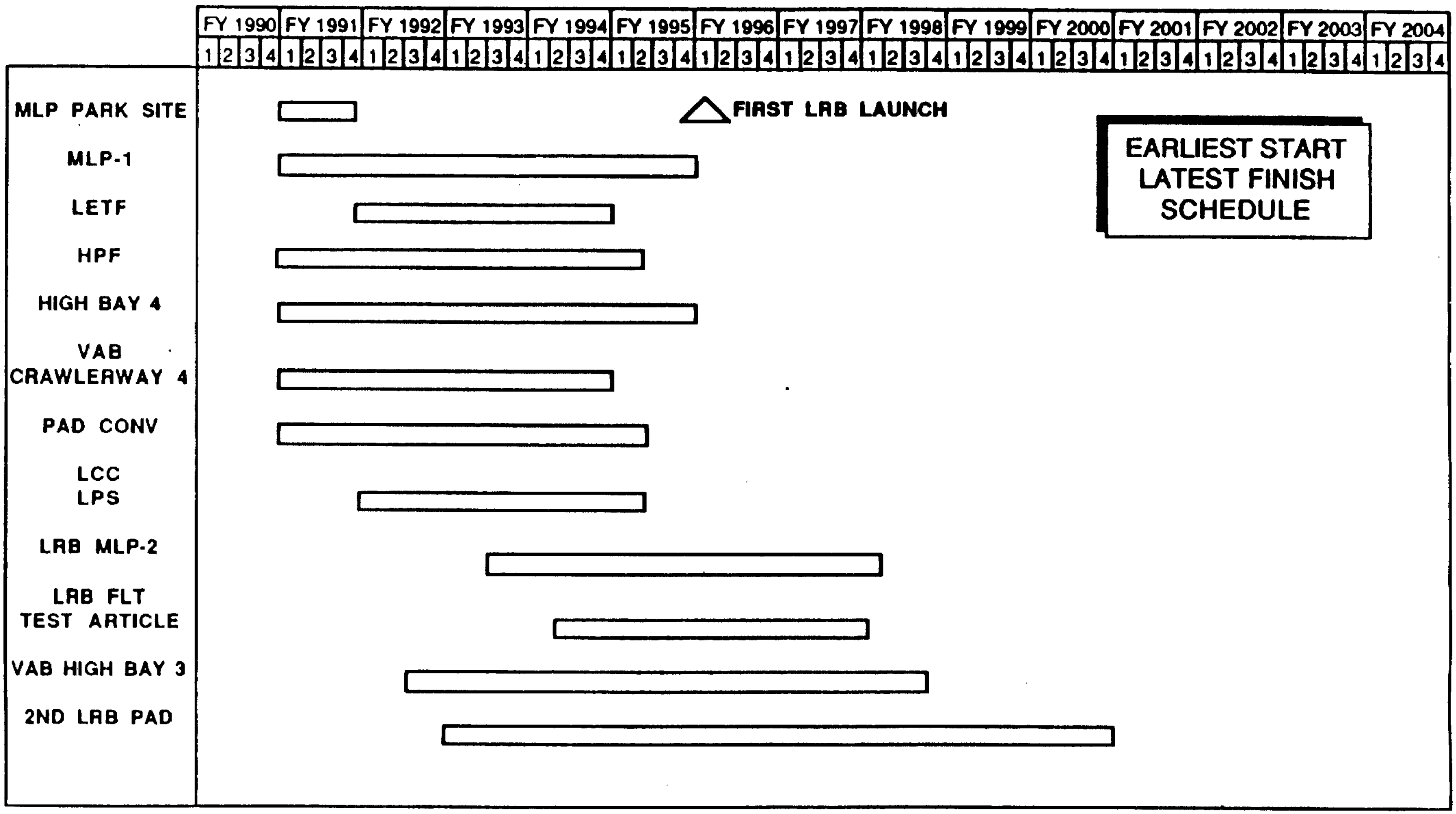

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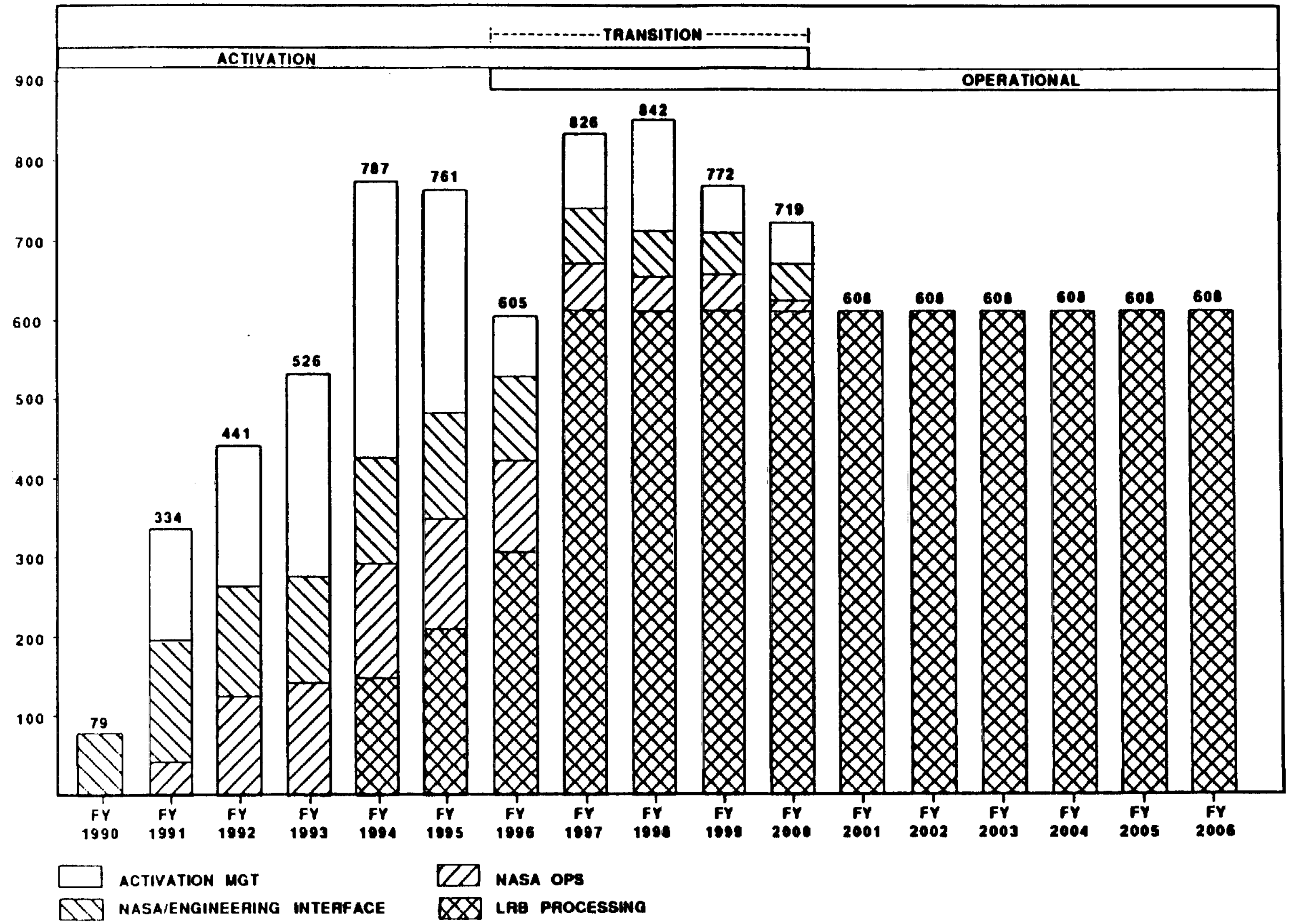
CUMULATIVE .RB MANPOWER



RECOMMENDATIONS FOR FOLLOW-ON STUDY

THE LRBI STUDY HAS IDENTIFIED A NUMBER OF ISSUES THAT WILL REQUIRE FURTHER STUDY AND IN-DEPTH ANALYSIS. WE SHOULD CONTINUE TO SUPPORT THESE CRITICAL ISSUES WITH THE DEVELOPMENT OF MORE RIGOROUS STUDY TOOLS AND MORE COMPLETE DATABASES. ADDITIONAL INFORMATION, AS IT BECOMES AVAILABLE FROM MSFC, WILL REQUIRE KSC LAUNCH OPERATIONS IMPACT ASSESSMENT. FOR INSTANCE, BOOSTER IMPACTS TO THE PAD WILL REQUIRE FURTHER DESIGN ANALYSIS. THE RESOLUTION OF THESE PROBLEMS WILL REQUIRE FURTHER SUPPORT AND COOPERATION WITH THE MSFC WORKING GROUP.

WE ALSO NEED BETTER TECHNIQUES TO PROVIDE IMPROVED ACCURACY IN DEVELOPING MIXED-MISSION SCHEDULES AND COST. THESE TECHNIQUES MIGHT INCLUDE ENHANCED VERSIONS OF THE ARTEMIS-BASED SRB/STS GROUND PROCESSING FLOW MODEL AND AUGMENTED EDITIONS OF THE GROUND OPERATIONS COST MODEL (GOCM). THE EXPANSION OF GOCM WOULD ALLOW MORE REFINED COST PROJECTIONS THAN CURRENTLY AVAILABLE WITH THE PRESENT PARAMETRIC MODEL.

WE SHOULD ALSO ASSESS ALTERNATIVE LAUNCH SITE CONFIGURATIONS AND SCENARIOS. WE CURRENTLY PLAN TO INTEGRATE THE LRB INTO ON-GOING KSC OPERATIONS. THIS ESTABLISHES A FORMIDABLE CONSTRAINT IN LRB GROUND OPERATIONS PLANNING. THUS, WE MUST EVALUATE A WIDE VARIETY OF LAUNCH SITE CONFIGURATIONS AND SCENARIOS IN ORDER TO FIND AND SELECT THE BEST ALTERNATIVES. THIS INFORMATION WILL BE VALUABLE NOT ONLY TO THE LRB EFFORT, BUT ALSO TO THE LRB-DERIVED PROGRAMS, SUCH AS UNMANNED SHUTTLES OR ALS.

RECOMMENDATIONS FOR FOLLOW-ON STUDY

- CONTINUE TO SUPPORT MSFC WORKING GROUP
- ENHANCE THE LRBI EVALUATION TECHNIQUES FOR MULTI-MISSION ASSESSMENT
- ASSESS ALTERNATIVE LAUNCH SITE CONFIGURATIONS AND SCENARIOS

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This study supplemented the Liquid Rocket Booster Studies performed by Martin Marietta and General Dynamics for NASA/MSFC under Senate contracts. Follow-on activities in Phase II (1989) and Phase III (1990) were performed and separate quarterly reviews were provided as documentation to Kennedy Space Center.

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13. ABSTRACT *(Maximum 200 words)*
The impacts of introducing Liquid Rocket Boosters (LRB) into the STS/KSC Launch environment are identified and evaluated. Proposed ground systems configurations are presented along with a launch site requirements summary. Pre-launch processing scenarios are described and the required facility modifications and new facility requirements are analyzed. Flight vehicle design recommedations to enhance launch processing are discussed. Processing approaches to integrate LRB with existing STS launch operations are evaluated. The key features and significance of launch site transition to a new STS configuration in parallel with on-going launch activities are enumerated.

The LRB Integration Study Final Report is presented in Five volumes as follows:

VOL I Executive Summary
VOL II Study Summary
VOL III Study Products
VOL IV Reviews and Presentations
VOL V Appendices

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